VOLUME XVIII NOVEMBER, 1927 NUMBER 5

DEC 8 1927

[FOUNDED [illegible] AS THE AMERICAN QUARTERLY OF ROENTGENOLOGY]

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

OFFICIAL ORGAN
THE AMERICAN ROENTGEN RAY SOCIETY
THE AMERICAN RADIUM SOCIETY

Editor: ARTHUR C. CHRISTIE, M.D.

EDITORIAL BOARD

JAMES T. CASE, M.D. H. K. PANCOAST, M.D. WILLIAM DUANE, PH.D.

ADVISORY BOARD FOR PATHOLOGY

JAMES EWING, M.D. Cornell University
EUGENE L. OPIE, M.D. University of Pennsylvania
ALDRED S. WARTHIN, M.D. University of Michigan

PUBLISHED MONTHLY FOR THE AMERICAN ROENTGEN RAY SOCIETY
BY PAUL B. HOEBER, INC., 76 FIFTH AVENUE, NEW YORK CITY

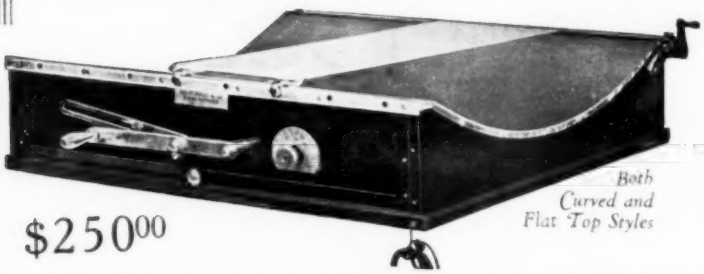
AMERICAN ROENTGEN RAY SOCIETY
Twenty-Ninth Annual Meeting · Kansas City, Mo. · 1928
DATE TO BE ANNOUNCED

AMERICAN RADIUM SOCIETY
Thirteenth Annual Meeting—TO BE ANNOUNCED

SECOND INTERNATIONAL CONGRESS *of* RADIOLOGY
Stockholm, Sweden · July 23-27, 1928

Entered as second-class matter, March 3, 1916, at the Post Office, New York, N. Y., under the Act of March 3, 1879.
YEARLY SUBSCRIPTION, $10.00 SINGLE NUMBERS $1.50

BRADY'S POTTER-BUCKY DIAPHRAGMS



Both Curved and Flat Top Styles

$250.00

NEW FEATURES

New and improved type of grid construction of high ratio, giving the finest detail and contrast. Patient brought nearer to plate.

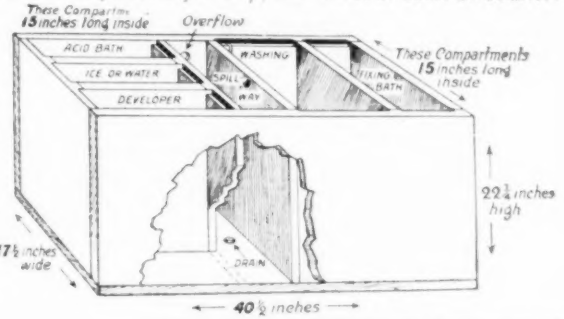
A neat compression band attachment for holding the patient still during exposure.

An electric contact device for operating the time switch to make exposures automatically from 1 to 60 seconds, $5 00 extra on Curved Buckies, included in Flat Bucky price.

Our speed control is accurate and reliable and timed in actual seconds. It does not require constant repairs. We claim ours are the smallest, neatest and most accurate and effective Buckies on the market, operating in horizontal or vertical position. Larger sizes take all make cassettes up to 17 x 17 size. Small Flat Bucky takes 11 x 14 or smaller. Has 6:1 ratio grid cutting off practically 90% of secondary. All-metal construction electrically welded and practically indestructible. They do not get "out of date." Curved style $250.00, 17x17 Flat style $260.00, 11x14 Flat style $175 00. Liberal cash discounts.

DEVELOPING TANKS

Our stone tanks are considered the best designs and values on the market. Each has a space for ice or hot water for controlling the developing temperature. The 5 and 6 compartment styles also have a 4" air space to prevent temperature of wash water from affecting the temperature of developer. Lengths over all 24½"-34"-40¼" respectively. Illustration shows our regular 6 compartment style. Special styles to order. We have many sizes of enamel tanks also. Send for special circular.



	4-compartment	5-compartment	6-compartment
Prices shipped from Virginia	$50.50	$56.50	$68.50
Prices shipped from Chicago, Boston or Brooklyn	$59.00	$67.25	$77.00

DR. GRANGER'S SINUS DEVICES

We furnish these to fit any make cassettes. Specify outside size of cassette when ordering for 8 x 10 only. Sphenoid Mask with proper angle block $13.00. Mastoid Localizer with angle block $27.00.

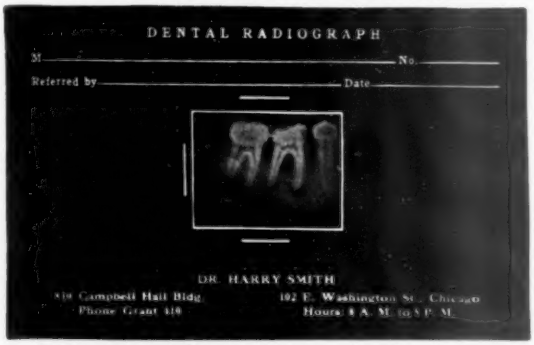
INTENSIFYING SCREENS

Get our net prices on screens either alone, or mounted in cassettes. It may save you some money. We are distributors on Buck X-Ograph cassettes, and carry the standard makes of screens.

BARIUM SULPHATE (Paragon)

We have furnished enormous quantities of this to the profession during the last 10 years. We are prepared to furnish this in prepared form with malted milk or dry milk incorporated at $30.00 per 100 lbs. packed in 25 lb. sealed tin cans. 5 lb. & 10 lb. sizes also available. Price of regular barium $24.00, fluffy style $26.00 per hundred.

DENTAL FILM MOUNTS

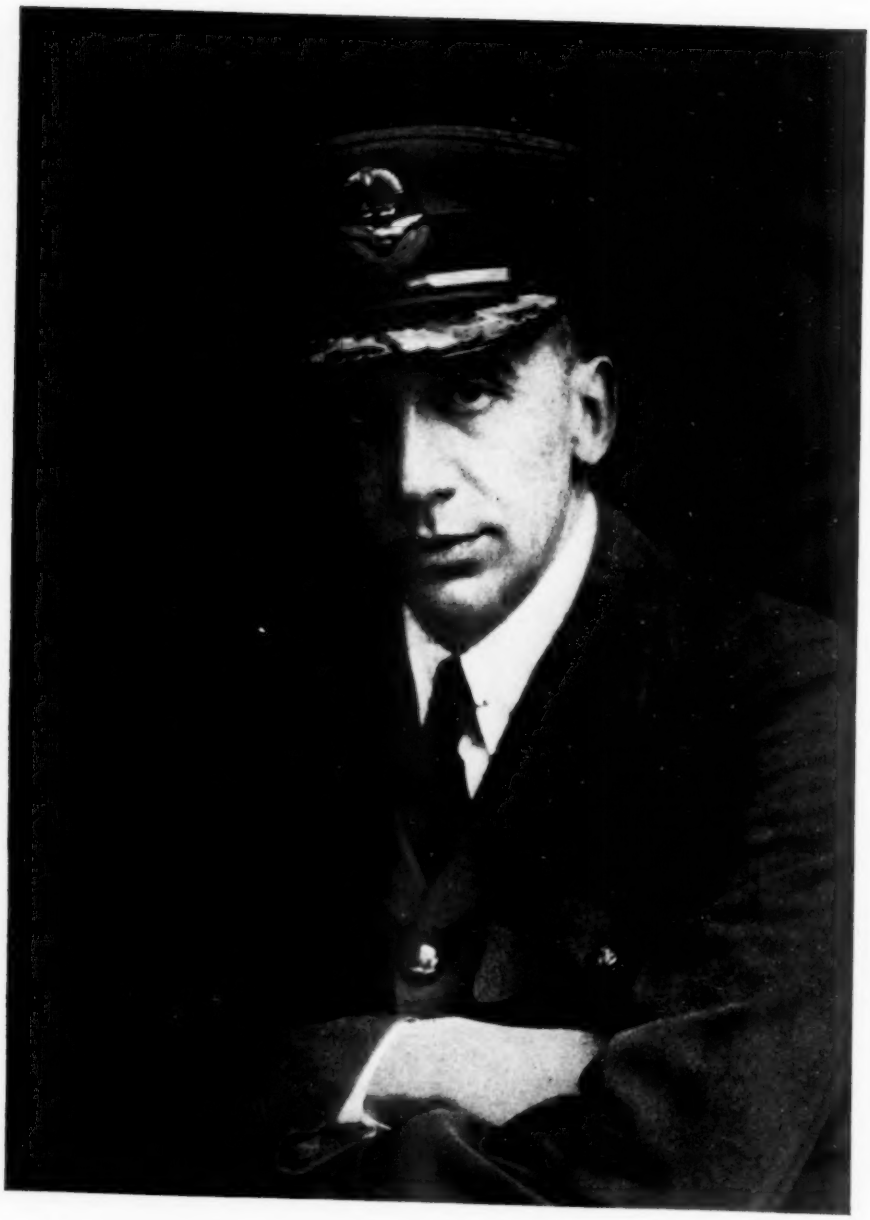


We can furnish many sizes and styles of mounts in cardboard or the all-celluloid types. Special designs if desired. Very liberal discounts are allowed on orders for 100 or more. Get our new price list #160—with discounts.

Special on gross lots of #1 size film $6.96.

ASK FOR OUR LATEST PRICE LIST AND DISCOUNTS

GEO. W. BRADY & CO., 761 S. WESTERN AVE., CHICAGO



G. W. C. Kaye

CALDWELL LECTURER 1927

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. XVIII NOVEMBER, 1927 No. 5

SOME FUNDAMENTAL ASPECTS OF ROENTGEN RAYS AND THE PROTECTION OF THE ROENTGEN-RAY WORKER

CALDWELL LECTURE, 1927*

BY G. W. C. KAYE, O.B.E., M.A., D.SC.

Superintendent of Physics at the National Physical Laboratory

TEDDINGTON, ENGLAND

LET me say at once how greatly I appreciate the honor of being invited by your Society to deliver this, the eighth Caldwell Lecture. So high a compliment from a country which has long held my admiration and regard, and in which I am proud to claim many friends, affords me an unaccustomed personal gratification which is deeper than I can find words to express. I feel, too, I am right in interpreting your action as a gesture of friendship towards the British Röntgen Society and Institute of Radiology, which, now happily united into one body, send their greetings on this memorable occasion when, for the first time in your history, you have met under a distinguished president of British birth in a great British Dominion which is this year celebrating its Diamond Jubilee.

The Caldwell Lecture was founded to commemorate annually the late Dr. Eugene Caldwell and his work and association with your Society. Dr. Caldwell's early training was that of an electrical engineer. Greatly intrigued by the discovery of the roentgen rays, and realizing their immense potentialities in medicine and surgery, he applied himself to the study of medicine and, after a few years, took a medical degree. His physical training stood him in good stead throughout his life: it was reflected, for example, in a precise and unrivalled technique. A born inventor, his skill and ingenuity went to devising roentgen-ray tubes and coils, self-centering tube stands, portable outfits and stereoscopic roentgenoscopes of special types. His name is associated with a well-known form of electrolytic interrupter. He clearly foresaw the advent of the constant potential generator, and long before the days of the Kenetron attempted to generate constant high voltage by using valve tubes to smooth out polyphase alternating current—pioneer experiments which were arrested by the war and that illness which in the end added another name to the long list of roentgen-ray martyrs.

Roentgenology owes a heavy debt to men of the type and training of Caldwell; and it is a duty and a privilege tonight to pay tribute to the memory of one who was much esteemed and beloved by his fellow workers.

* Delivered at the Twenty-eighth Annual Meeting, AMERICAN ROENTGEN RAY SOCIETY, Montreal, Canada, Sept. 20–23, 1927.

SOME EARLY PHILOSOPHERS

It is now nearly thirty-two years since Roentgen's world-famous discovery, and we honor him as the prime founder of our science. Before passing on, we should, I think, find it instructive and certainly not uninteresting to spend just a few minutes with some of those pioneer philosophers of the 17th and 18th centuries who, toiling patiently, often in the face of the greatest difficulties, devised apparatus and developed theories which helped to blaze the trail to the electric discharge tube and so to Roentgen's X-rays. It mattered little that few of the theories stood the test of time for, to quote Sir J. J. Thomson's aphorism in his Silvanus Thompson lecture before the Röntgen Society in London a few weeks ago: "A scientific theory is a policy and not a creed." Moreover, theories, particularly if they are simple and easily visualized, serve to stimulate inquiry and systematize experiment. Furthermore, even when a theory is ultimately wrecked, there is not unusually a little salvage to incorporate into the next tentative working hypothesis.

It is interesting and curious that the very earliest records of electrical phenomena are in some way associated with medicine. For example, Pliny and other classical writers described the remedial uses of the electric torpedo fish. Again in the middle ages the confused notions of the alchemists were first clarified by Gilbert (1540–1603), physician to Queen Elizabeth and president of the Royal College of Physicians. It is acknowledged that Gilbert to whom we owe the word electricity (though in the adjective), laid the foundations of the science of electricity in his monumental work "De Magnete:" it was a grievous loss when his apparatus and books were destroyed in the Great Fire of London in 1666.

We may pass to Torricelli, friend and pupil of Galileo, who in Italy in 1643 discovered the vacuum produced by a barometric column of mercury. This discovery laid the foundation of the many kinds of mercury pumps which were designed during the 18th and 19th centuries. The two outstanding examples of such pumps, the one due to Töpler (1862), the other to Sprengel (1865) were used, as many of you will recall, to exhaust the tubes of all the early roentgen-ray workers.

A contemporary of Torricelli, but working quite independently, was Otto von Guericke, who in Germany about 1650 not only constructed the first mechanical air pump but devised the first frictional electrical machine—two events of the first importance in the genesis of the discharge tube. Von Guericke had a curious idea in his mind which he hoped to settle when he devised the air pump. He had long been interested in the motion of the stars in the heavens and had come to the conclusion that they must be moving through an empty space, for otherwise they would gradually be stopped by the resistance of the air. He therefore decided to try to make an empty space, the better to study the question at close quarters. As regards his electrical machine, it consisted of a ball of sulphur which could be rotated while the hand was pressed against it.

Von Guericke was followed by, among others, Robert Boyle (about 1660) and Hauksbee (about 1705), sometime Curator of Experiments to the Royal Society in London. The latter was probably the first to conduct experiments on electric discharges *in racuo*. This came about from his curiosity concerning the curious flickering luminescence which is occasionally seen in the vacuum of a barometer tube, when the mercury is caused to oscillate in the dark—an effect frequently referred to in the writings of the times. "Mercurial phosphorus," Hauksbee called it, and, subsequently, in the belief that the explanation lay in some electrical action, he succeeded in simulating the effect by holding the hand against a rotating evacuated glass globe. Later he obtained "a fine purple light" by rotating within an exhausted bell jar, a small electrical machine depending on the "attrition" of wool against glass or amber. "Sometimes," he says, "I have observed the light to break from the agitated glass in as strange a form as lightning." Possibly the first reference in literature to electric sparks appears in Hauksbee's writings: "If a hand was held near the fricated glass a light would be seen to dart from it with a noise

like that of a green leaf in the fire." Hauksbee was inclined to attribute the release of the electric "effluvium" to the heating produced. His beautiful two-cylinder vacuum pump is happily still in the possession of the Royal Society. It was carefully overhauled last year and, although over two hundred years old, is even now capable of pumping down to about 1 inch of mercury.

Wall, a contemporary of Hauksbee, was evidently somewhat successful in generating electric sparks in air by the rubbing of amber with wool. "Five or six cracklings or more, full as loud as that of charcoal on fire, have been produced. They seemed," he says, "in some degree to represent thunder and lightning." He concluded that "the best time of making these experiments is when the sun is 18 degrees below the horizon!"

In 1730 Stephen Gray discovered that metal wires conducted electricity, and in 1740 the Abbé Nollet, preceptor in natural philosophy to the French Royal Family, turned this to account and repeated Hauksbee's results by connecting a frictional electrical machine by wires to an exhausted egg-shaped vessel—"the electric egg" he called it, and the term, which persisted for many years, is not an unsuitable one for the prototype of the roentgen-ray bulb.

That great American philosopher and statesman, Benjamin Franklin (1706–90), is intimately associated with the succeeding developments in static electricity. His famous and daring kite experiment in 1749, to demonstrate the electrical nature of lightning, is known to every schoolboy. He formed the opinion that "the electrical matter consists of particles extremely subtle," and he clearly recognized the properties of metallic points "in drawing on and throwing off the electrical fluid." Franklin's one-fluid theory of electricity commanded acceptance for over 150 years, though incidentally at the time it gave great offence to the Abbé Nollet, who was the protagonist of other views. There seem to have been three kinds of electricity in those days: Franklin electricity, Nollet electricity and Italian electricity, the last variety, "enjoying the prerogatives," as Nollet sarcastically puts it, of transmitting odors and drugs through glass phials or along chains, and indeed into the human system if the phial or chain were held in the hand!

The Leyden jar was discovered in 1745, and Franklin was persuaded about 1757 to investigate the curative value of Leyden jar discharges, miraculous claims for which were then being made: his sober and candid conclusions stand out in marked contrast to some of the exaggerated statements of the time. However it was not all time wasted, for Franklin extended his experiments to fowls and, as "he conceited that birds killed in this manner eat uncommonly tender," he arranged "an electrical dinner" for his friends, in which a turkey, killed by an electrical shock, was subsequently roasted in front of an electrically ignited fire!

It seems not unlikely that the first experimenter to generate X-rays—had he but known it—was Morgan, who in London in 1785, by previously boiling and so outgassing the mercury in a barometric "gage," was able to obtain so good a Torricellian vacuum that an electric discharge either excited "a beautiful green light" or was prevented from passing at all.

Thus by the end of the 18th century the electric discharge tube was an established thing. Progress was more rapid during the 19th century when numerous workers with honored names helped to further the development—Davy, Faraday, Henry, Plücker, Rhumkorff, Geissler, Hittorf, Goldstein, Crookes, Lenard, J. J. Thomson, and many others. It is no part of my object tonight to dwell on these later and more familiar developments nor on the culminating triumph which in 1895 rewarded Roentgen's search for "invisible rays" from the discharge tube. We may recall that, within a few days of Roentgen's announcement and before any details had been transmitted from Germany, Prof. Cox of McGill University successfully generated the rays and turned them to practical account.

THE NATURE OF ROENTGEN RAYS AND SOME FUNDAMENTAL PROPERTIES

One is tempted to dwell on the subsequent growth of as fascinating a subject

as any which science has revealed to us, but the story has been told so often that we must confine ourselves to a few very recent fundamental features.

It was Roentgen himself who styled his new and unknown radiation the "X rays;" and the name has persisted, for it was not till 1912 that the complete answer to the problem of the nature of the rays came with the experimental demonstration in Germany by Friedrich and Knipping of the correctness of von Laue's masterly conception of the probability of their diffraction by the orderly spacing of the atoms in crystals. As he anticipated, the results went to show that the wave length of ordinary roentgen rays is of the same order as the atomic spacings, that is, about 10^{-8} cm. or 1 Angström unit.

The roentgen rays have now taken their place in that great array of ethereal vibrations, the various groups of which are each associated with some outstanding physical property. The spectrum of radiations (Fig. 1) extends without break over a range of 60 octaves—from radio or wireless waves, through heat waves, visible waves, ultraviolet waves, roentgen rays and gamma rays. Then follows a gap of about 2 octaves before we come to the "cosmic rays" first demonstrated in 1902 by Cooke and Rutherford at Montreal, and by McLennan and Burton at Toronto, subsequently investigated among others by Wright in the Antarctic, and by Kohlhörster with balloon observations, and recently confirmed and extended by Millikan at Pasadena. The gamut of wave lengths of this spectrum of radiations is truly gigantic, amounting to a million, million, million fold, for the wave lengths range from about 30 kilometers (20 miles) in the case of radio waves, to about 5×10^{-11} cm. in the case of gamma rays, and about 5×10^{-12} cm. in the case of the cosmic rays.

Within the last two or three years the gap between radio waves and heat waves has been closed, while the gap between the ultraviolet and roentgen-ray groups has been bridged by the aid of vacuum spectrometers and photoelectric methods of analysis. This latter intervening group of very absorbable radiations, for which incidentally we need a handy and distinctive name,* have been shown to conform to the established roentgen-ray laws throughout their range right into the ultraviolet. Sir J. J. Thomson[1] has recently demonstrated that these very soft roentgen rays are generated within an ordinary discharge tube, but they are so absorbable that they never emerge through the walls of the tube as ordinarily constructed. They possess pronounced ionizing ability, and it is not impossible that the more penetrating of these border-line radiations might, under proper conditions, prove to possess useful properties in superficial treatment.

Now, although the complete identity of roentgen rays and light waves was not

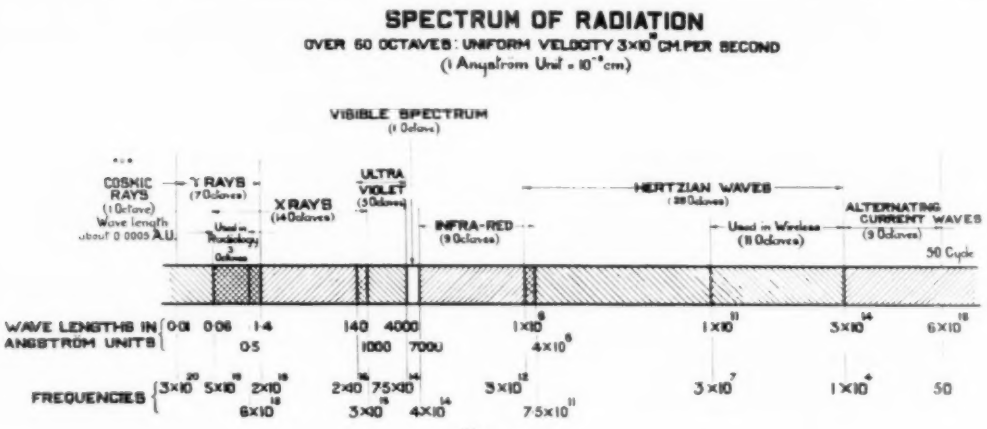


FIG. 1.

* In the absence of a better suggestion it might perhaps be remarked that, as there are U.V. rays on the one side and X rays on the other, the alphabetical sequence would be complete if these absorbable rays were called W rays.

established until just before the war, it had been correctly inferred by one school of workers on the score of the several features of resemblance, for example, their linear propagation, their ionizing, fluorescing and photographic activities, and their electrically neutral character. Furthermore, Barkla (1905) in England and his contemporaries had succeeded in establishing a partial polarization in the case of scattered roentgen rays somewhat akin to that of light.* Then, too, Marx in Germany carried out elaborate and ingenious experiments in 1906 which he claimed established the agreement of the velocity of roentgen rays with that of light. The experimental arrangements were the subject of criticism at the time, and Marx repeated his experiments in 1910. The correctness of the result is no longer in doubt, though no recent work on the subject appears to have been done. Again, Haga and Wind conducted very difficult experiments in 1899–1901 to try to detect diffraction fringes by passing heterogeneous roentgen rays through a very narrow slit. They obtained a broadening of the image on a photographic plate which led them to a value in the neighborhood of 10^{-9} cm. for the wave length of roentgen rays. The experiments were adversely criticized by Walter and Pohl on the strength of more refined measurements made in 1909, but some three years later Sommerfeld redigested Walter and Pohl's own data and found support for Haga and Wind's conclusions. Wave lengths agreeing with present day order of values were also derived by Wien in 1907, and Stark in 1908 from calculations based on Planck's theory of radiation.

But in some other respects the parallelism of light and roentgen rays seemed in the early days to break down, for example, as regards reflection and refraction. Among others, Roentgen himself endeavored in 1896 to test the refrangibility of roentgen rays, employing for the purpose prisms of carbon bisulphide, water, ebonite, aluminum and heavier metals. He further tried to focus the rays with lenses of ebonite and glass.

We now know that such experiments were not of a kind to justify any hope of success, but searching attempts were made by later workers in the light of the Drude-Lorentz theory of dispersion. For example, Barkla[4] attempted to refract with a 90° prism of potassium bromide crystal a narrow pencil of heterogeneous roentgen rays of a range of frequencies including the resonance frequency of bromine (wave length about 0.5Å). He could, however, detect no sign of refraction and concluded that the refractive index differed from unity by less than 0.000005—a figure of the right order, as we shall presently see.

It is only within the last few years that success has been attained. A. H. Compton at Chicago (1922), Siegbahn in Sweden, Bergen Davis in New York and others have displayed the specular reflection of roentgen rays, the refraction by prisms, and, furthermore, the diffraction by ruled gratings. These experiments are of great fundamental interest to all roentgen-ray workers and may well receive a share of our attention this evening. Some of the results form part of the rich harvest which is being gleaned from the large amount of roentgen-ray research now being carried out under Coolidge, Compton, Duane, Davis and many others in the great industrial and university laboratories of America.

TOTAL REFLECTION OF ROENTGEN RAYS

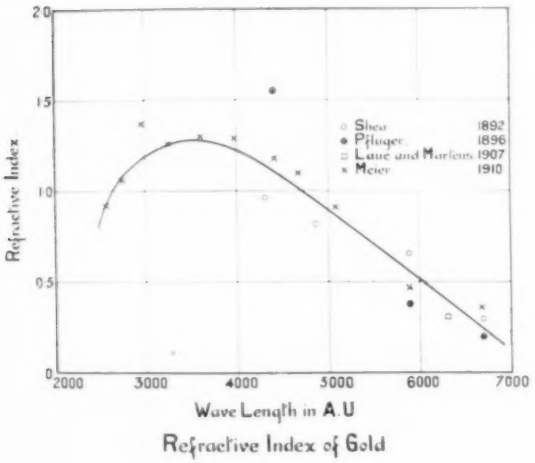
It follows from the classical Drude-Lorentz theory of dispersion that, if the frequency of the incident radiation is large compared with the natural frequency of the electrons encountered in a medium—as is the case when roentgen rays of ordinary wave length are incident on light atoms—then the refractive index of the medium increases with the frequency of the radiation but is always less than unity. In other words, the velocity of roentgen rays is greater in the medium than *in vacuo*. This presents an interesting case of the difference between wave velocity and group velocity. Refractive indices less than unity are, of course, also known in the transmission of visible light by metals. (For example, see Figure 2 which refers to the case of gold.)

The value of the refractive index μ for

* Since then with improved experimental arrangements Compton and Hagenow[2] have obtained almost complete polarization of scattered rays. Further Bishop[3] has recently obtained results which indicate partial polarization of characteristic roentgen rays.

roentgen rays in the circumstances stated is given approximately by the Lorentz theory as

$$\mu = 1 - \frac{ne^2}{2\pi m\nu^2}$$



Refractive Index of Gold

FIG. 2.

where n is the number of active electrons per unit volume, e is the charge on the electron, m is the mass of the electron, and ν is the frequency of the radiation.

Compton[5] computed by this formula the theoretical values of μ for calcite. They proved to be less than unity by quantities of the order of 10^{-6}, the refractive indices ranging from 0.999992 to 0.999996 for wave lengths from 1.47 to 1.10A.

But other evidence had also been accumulating, for if roentgen rays have an appreciable refractive index, then, as Darwin[6] at Edinburgh had pointed out some years previously, Bragg's well-known simple relation for crystal refraction

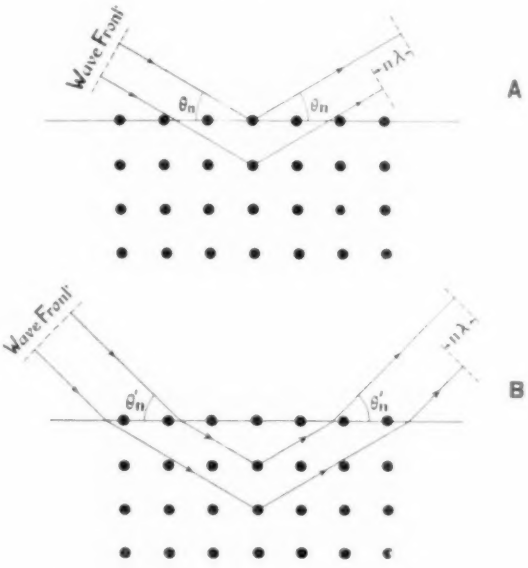
$$n\lambda = 2d \sin \theta_n^*$$

will not be strictly obeyed. That is, the ratio

$$\frac{\lambda}{2d} = \frac{\sin \theta_n}{n}$$

will not be a constant for all orders of reflection. In other words, as Figure 3 shows, the measured value of the reflecting angle θ_n will be slightly too great and so give too large a value of the wave length λ. The discrepancy will be greatest for the first order spectrum, but as θ_n increases with the order the refraction will exert relatively less and less effect and so the error in λ will be proportionately reduced.

* d is the atomic spacing.
θ_n is the reflecting angle for the nth order.
λ is the wave length.



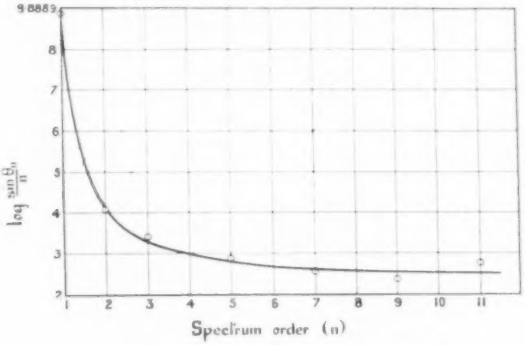
A. Illustrating Bragg's law of Crystal Reflection $n\lambda = 2d \sin \theta_n$

B. Illustrating the effect of refraction in slightly increasing the measured value of θ_n

FIG. 3.

Darwin's correction leads to an amended form of Bragg's relation

$$n\lambda = 2d \sin \theta_n \left(1 - \frac{1-\mu}{\sin^2 \theta_n}\right)$$



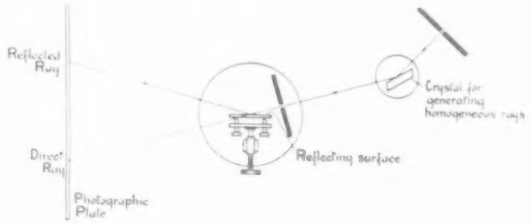
Mica: $CuK\alpha_1$ radiation (Larsson)

FIG. 4.

Increasing precision in roentgen-ray spectrometry by Stenström in Sweden in

1919, Duane and Patterson at Harvard in 1920, and Siegbahn in 1921, confirmed the point experimentally: the ratio $\sin \theta_n / n$ is not quite constant, but decreases slightly as n increases. This is well illustrated in Figure 4 based on the results for mica obtained by Larsson[7] in Siegbahn's laboratory. The correspondence between the experimental values of $\sin \theta_n / n$ (for different orders from the first to the eleventh) and the theoretical curve embodying Darwin's correction is very close.

Furthermore, Compton[5] computed the values of μ by the modified Bragg equation, utilizing Duane and Patterson's data for



Total Reflection of X Rays
Compton and Doan

FIG. 5.

calcite, and found results in excellent agreement with those calculated, as mentioned above, from the Lorentz theory. We may take it as established that refraction is the true explanation of the consistent dependency of the apparent wave length upon the order of reflection.

Now, since the refractive index of roentgen rays is less than unity, then if the glancing angle θ in the case of rays travelling in air and incident on the medium is such that

$$\cos \theta = \mu$$

then the rays should, as in the case of light, be totally reflected, no matter whether the medium is crystalline or amorphous. Let us take the case of a crown-glass mirror of density 2.52 and roentgen rays of wave length 1.28 A, then the Lorentz dispersion formula above gives $\mu = 0.999995$, so that the critical glancing angle $\theta = 11$ minutes of arc. On putting the experiment to the test, Compton, using an ionization method and a very narrow roentgen-ray beam, was able to detect specular reflection close to the position predicted. Energy measurements showed that almost all the incident energy was reflected, as would be anticipated in a case of true total reflection.

It may be of interest to give Compton's experimental values of the refractive indices and the critical glancing angles.

Substance	Density	Wave Length λ	Critical Glancing Angle θ	Refractive Index μ
Glass	2.52	1.28	10′	0.999996
Glass	2.52	0.52	4′	0.999999
Silver	10.5	1.28	22.5′	0.999979

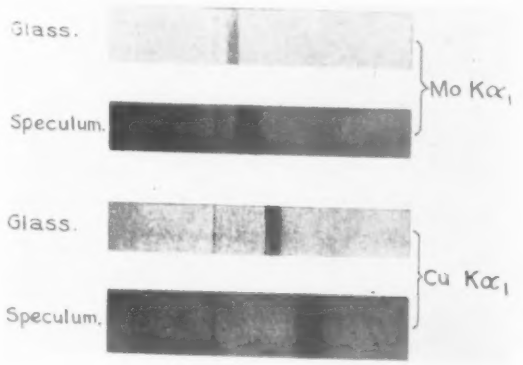


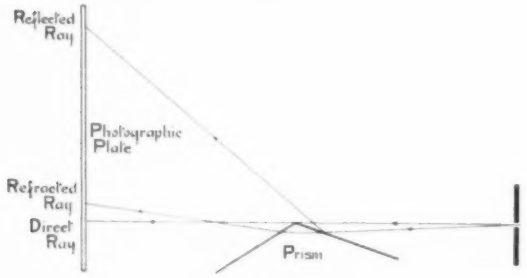
FIG. 6. From Doan.

Incidentally, Compton's measurements afford an independent and reliable confirmation of the accepted result that the number of active electrons in the extra nuclear region of the atom is equal to the atomic number. Furthermore, the phenomenon of total reflection provides a means of filtering out the *short* waves from a composite beam of rays, a thing not possible with absorption filters. Surfaces of the heavier metals are more convenient for the purpose, as the critical glancing angles are rather larger. Unfortunately, from a practical point of view, the method is only applicable to very narrow pencils of rays.

Kirkpatrick[8] in Hawaii subsequently obtained photographs of total reflections from surfaces of lead and sputtered platinized glass. Doan[9] at Chicago, also using a photographic method, has recently extended the scope of Compton's work on total reflection to include a number of sputtered metal surfaces, e.g., copper, silver, nickel,

gold and speculum. Of these gold exhibited the largest critical glancing angle (31′ 24″ for Cu $K\alpha_1$ radiation) and the smallest refractive index (0.999958 for Cu $K\alpha_1$ radiation). Figure 5 shows Doan's experimental arrangements and Figure 6 some of the photographs obtained. In practice it is found that both the sharpness and intensity of the reflected spectrum depend upon the degree of polish of the surface.

Within the last few weeks Prins[10] at Groningen, has succeeded in producing multiple reflection of roentgen rays between



Reflection and Refraction of X Rays by glass prism
Siegbahn, Larsson and Waller.

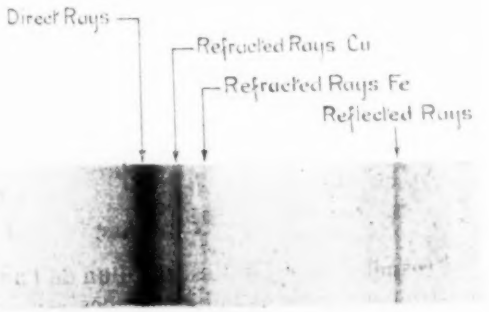
FIG. 7.

two parallel stainless-steel mirrors about 0.005 cm. apart.

PRISMATIC REFRACTION OF ROENTGEN RAYS

Now that we know the extent of the very small divergence of the refractive index of roentgen rays from unity, it should be possible to arrange the conditions so that the minute prismatic bending of the rays may be detected. This was first accomplished photographically by Siegbahn, Larsson and Waller.[11] They used heterogeneous rays and a glass prism, the refracting angle of which was large so as to enhance the deviation. Figure 7 shows the arrangement. If the glancing angle is very small two lines appear on the photographic plate due to the direct and reflected beams respectively. As the glancing angle is increased through the critical angle, the reflected ray disappears and a refracted ray appears in a position indicating a bending of the beam in a direction opposite to that of normal optical refraction. Figure 8 shows on the one plate the direct and reflected rays as well as the refracted spectrum of a pencil of rays which includes the $K\alpha$ rays of copper and iron. The refractive index of the glass prism (density 2.55) was found to differ from unity by from 1 to 12 in the 6th place for wave lengths ranging from 0.63 to 1.93 A.

Davis and Slack,[12] and Slack,[13] using the double ionization spectrometer, found the deviation when roentgen rays were refracted by a number of metal prisms to be only a few seconds of arc. The following are some of their results:



Reflection and Refraction of X Rays by glass prism.
Siegbahn, Larsson and Waller.

Substance	Wave Length A	Prism Angle	Angle of Deviation	Refractive Index μ
Silver	0.708	63.5°	2.4″	0.999994
Copper	0.708	60.0	2.1	4
Sulphur	0.708	168.3	5.4	8
Aluminum	0.708	166.0	5.6	8
Carbon	0.708	86.4	4.0	8

FIG. 8.

Incidentally, Davis greatly increased the deviations with certain crystals by grinding the reflecting planes to suitable angles. Mention may also be made of the application of roentgen-ray refraction by Davis and Nardroff[14] to the measurement of the size of small particles. The method appears to afford some hope of measuring in certain cases the size of small particles far beyond microscopic size, possibly as small as 10^{-7} cm.

DIFFRACTION OF ROENTGEN RAYS BY RULED GRATINGS

Until recently, roentgen-ray spectroscopy rested entirely upon diffraction by crystals, after the method due to Bragg. For this we require a knowledge of the atomic spacing which it will be recalled is calculated in the case of some standard crystal such as calcite or rock salt by means of the relation which, in its simplest form, is

$$d^3\rho = M$$

where d is the atomic spacing in cm., ρ is the density (gram c.c.), M is the weight of the molecule in grams.

By this means W. L. Bragg[15] first found the atomic spacing for rock salt, the latest value of which is

$$d = 2.814 \times 10^{-8} \text{ cm.}$$

while Siegbahn's latest figure for calcite (cleavage face) is

$$d = 3.029 \times 10^{-8} \text{ cm.}$$

and these are generally adopted as standard values.

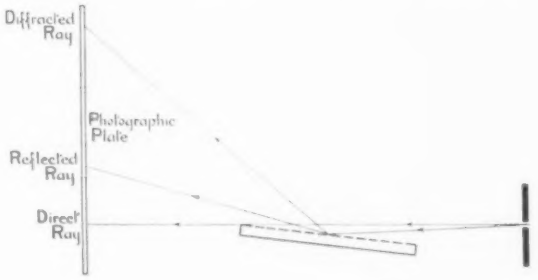
The value of M is dependent on that adopted for the Avogadro number, i.e., the number of molecules per cubic centimeter of a gas, and, as Siegbahn has pointed out, the technique of roentgen-ray spectrometry has now reached a stage of development when the accuracy of measurement of the angle of reflection is greater than that attainable in the calculation of the atomic spacing, for which the accumulative uncertainty in the value of the density, the charge on the electron, etc., amounts to about 2 parts in 3000.

It had always been taken for granted that ordinary optical diffraction gratings were much too coarsely ruled for dealing with waves as short as roentgen rays; but it is evident that, by employing extremely small glancing angles, the difference in the paths of the waves reflected by adjacent rulings will become such that the diffraction of roentgen rays may be rendered possible—a suggestion which was first put forward by Carrara.[16]

The production of such spectra was, however, first demonstrated by A. H. Compton with Doan[17] who used a reflection grating on speculum metal with 500 lines to the centimeter. If any considerable fraction of the energy is to be reflected, it is necessary to work within the critical glancing angle for total reflection, i.e., about 25′ for wave lengths less than 1.6 A. By the use of a photographic method under these conditions the diffraction effect was completely established.

Compton and Doan cite the following example of the agreement between the results of the ruled grating and the crystal grating methods in the case of the molybdenum $K\alpha_1$ line:

By ruled grating $\lambda = 0.707 \pm 0.003$ A
By crystal grating $\lambda = 0.7078 \pm 0.0002$ A



Reflection and Diffraction of X Rays by ruled grating.

FIG. 9. From Thibaud.

Thibaud[18] has recently extended Compton's work, using a glass reflecting grating with 2000 lines per cm. Figure 9 shows the experimental arrangement, and Figure 10 is a typical photograph showing the direct beam of rays, the totally reflected beam, and the diffracted spectrum, the sharp lines of which include the α and β lines of the CuK series. As the glancing angle is increased through the critical value the reflected and diffracted beams disappear simultaneously. Thibaud gives the following results for the $CuK\alpha$ line:

By ruled grating $\lambda = 1.540$ A (to about 1%)
By crystal grating $\lambda = 1.538$ A

We are thus no longer wholly dependent on the crystal grating method for measuring roentgen-ray wave lengths; and when the technique and accuracy of the ruled grating method are improved, as they require to be, we shall be provided with a valuable alternative method which moreover is absolute. We can too, if we desire, conduct a direct comparison of roentgen-ray and optical wave lengths for the same

grating. Incidentally, the agreement already obtained between the results given by the two kinds of gratings, provides assurance, if it were needed, of the sound foundations on which crystal analysis rests.

An obvious field for this ruled grating method is in the region between roentgen rays and ultraviolet rays. Apart from photoelectric methods, progress in this absorbable region has been chiefly effected by the use of crystal gratings of the fatty

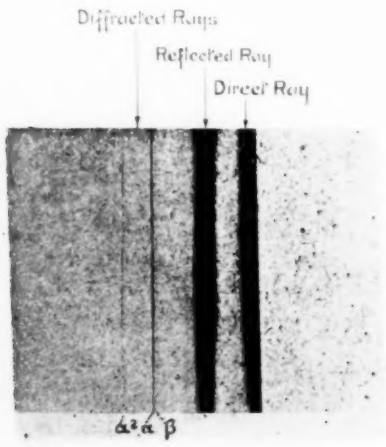


FIG. 10. From Thibaud.

acids, such as lauric, palmitic and stearic acids, the interplane molecular spacings of which, as Müller and Shearer,[19] working at the Royal Institution in London, first showed, range up to 60 or 70 A.

By mounting such crystals in a vacuum spectrograph Thoraeus,[20] working in Siegbahn's laboratory, has extended roentgen-ray wave length measurements up to the L series of chromium (21.5A) (Fig. 11). Early this year Dauvillier[21] also published results, taking matters considerably further into the region of longer waves.

Progress by such means is difficult, however, owing to the fact that a finite, if small, depth of the crystal must be penetrated to produce diffraction, and presently as the waves lengthen they become too absorbable to permit even this.

However, Thibaud[22] in a paper published a few weeks ago has successfully applied the ruled grating method to the absorbable region as far as 65 A. Glass gratings were used having either 2000 lines per cm. or 11,800 lines per cm., the spacing being checked optically by one of the green mercury lines. The K lines of carbon and oxygen were obtained in sharp definition, the absolute accuracy being about 1 in 200 (Fig. 12).

Mention should also be made of the recent experiments of Walter[23] who in

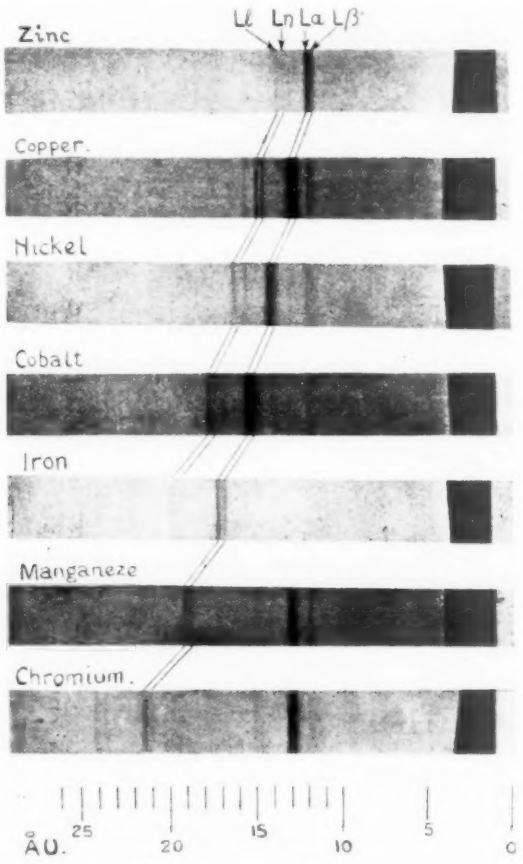


FIG. 11. From Thoraeus.

1924 returned to his earlier investigations on the diffraction of roentgen rays by narrow slits. In this later work Walter, using homogeneous rays and slits as narrow as 2×10^{-4} cm., obtained first and second order fringes giving wave lengths for copper K radiation within ± 10 per cent of the accepted figure (Fig. 13).

THE NATURE OF RADIATION

Thus, to sum up, what may be called the optical requirements of the classical and long established electromagnetic wave theory are now completely met by the roentgen rays. This is not to say, however, that we are any nearer to a solution of the nature of roentgen rays or indeed of radiation in general. On the contrary, side by side with the above "optical" investigations have been developed other roentgen-ray researches equally fundamental, the

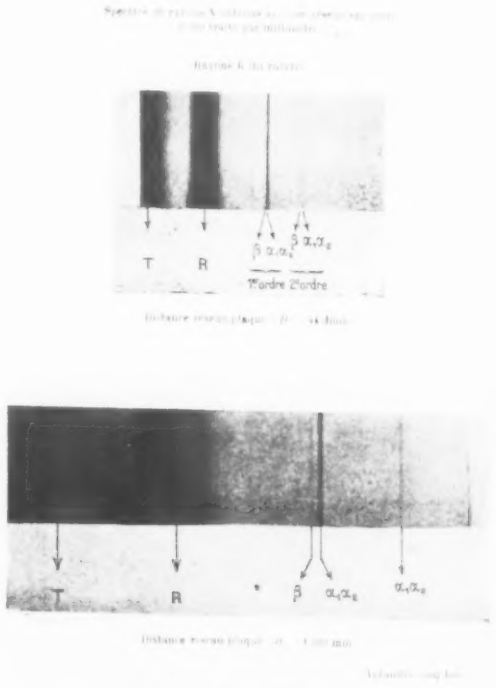


FIG. 12. From Thibaud.

results of which are not only unpredictable on a spreading wave theory but greatly strengthen the case for the quantum theory of radiation, which in effect regards roentgen rays as so many tiny projectiles or "quanta," much like the corpuscles in Newton's theory of light. The quantum theory contemplates these "projectiles" as possessing energy proportional to their frequency; and the theory achieves its greatest successes in explaining those electrical and energy phenomena which become more conspicuous as the frequency increases. The outstanding recent example is the Compton effect, that is, the small increase in wave length which is produced when hard roentgen rays are scattered by free electrons. The Compton effect is unexplained by the continuous wave theory, but receives very simple and quantitative explanation on the quantum theory by the notion that a quantum of roentgen rays may be scattered by a single electron, much as one billard ball is deflected by another. The roentgen-ray quantum loses a certain amount of energy in the encounter and this energy is taken up by the recoiling

FIG. 13. From Walter.

electron, the amount of energy transferred and the relative directions of the scattered quantum and the recoil electron depending on the conditions, such as the angle of scattering. This has been beautifully displayed by the cloud chamber method due to C. T. R. Wilson.

The doctrine of discontinuity that the quantum theory of radiation postulates is an important example of a conception that is gradually permeating fundamental physics at the present time. Even the so-called laws of nature are beginning to be

looked upon not so much as inherently simple and fundamental relations, but rather as mere expressions of something essentially statistical and which indicate nothing more than the most likely trend of events. We find another illustration in the primordial atom of Dalton which, small as it is (diameter 10^{-8} cm.), is, as you are aware, no longer regarded as continuous in structure, but as consisting of electrons (of diameter about 3×10^{-13} cm.) and even smaller protons (with diameters estimated at about 6×10^{-16} cm.). Furthermore, there is no evidence that even the electron or the proton is structureless; and in the Silvanus Thompson lecture already referred to, Sir J. J. Thomson did not hesitate to take things a step further and to invoke the assistance of particles much smaller even than the proton. There is obviously no finality; it is all a question of the fineness of the test that we presently apply to our theory. Even Maxwell's famous sorting demon, though thoroughly at home with the doctrine of discontinuity, might wonder at the increasing elaboration of his former simple molecules.

To return to the physics of radiation, we see that the difficulties of the problem have not been clarified but rather accentuated by some of the recent investigations on roentgen rays. All the electrical and energy phenomena point to a quantum theory, but this, even on the assumption of a partial coherence of quanta, still fails to explain interference which is most adequately accounted for by the spreading wave theory. As Sir J. J. Thomson has remarked, the conflict between the two theories has some of the features of a fight between a tiger and a shark: each is supreme in its own element and helpless in the other. The master theory which will reconcile the modern and the classical points of view is not yet in sight, and we are left confronted with one of the two great problems of modern physics—the structure of the atom and the structure of radiation.

ROENTGEN-RAY PROTECTION

And now, in a Caldwell Lecture, it would not be inappropriate for me to say something on the efforts which have been made in recent years to put an end to the danger of roentgen rays to those in their proximity, and to improve the general working conditions of the operator. I am aware that a good deal has been done in this connection on your side of the water, particularly by your Safety Committee, but you will forgive me if my remarks refer mainly to the work carried out in my country, because that is the side with which I happen to be most familiar.

The mischievous effects of the roentgen rays made themselves felt very early. In 1896 Edison and Dr. J. W. Morton experienced severe smarting of the eyes: the same year roentgen-ray dermatitis was noticed, the following year cases of pronounced constitutional symptoms were observed. Since then many cases resulting from overexposure under faulty working conditions have been recorded. It is estimated that well over a hundred of the earlier workers have succumbed to their injuries, while the large number of lesser casualties cannot be estimated. The great war must have added greatly to the list.

A succession of deaths from aplastic anemia brought matters to a head in England in 1921. Public opinion was stirred and the assurance companies began to regard the roentgen-ray worker with an unfavorable eye. As the result of co-operative action between the various British radiological and physical institutions, a representative committee of radiologists, physicists and manufacturers was set up in April, 1921, under the chairmanship of Sir Humphry Rolleston, then President of the Royal College of Physicians, and three months later issued a series of recommendations. These recommendations (which were revised and extended in May this year), though naturally they have not wholly escaped criticism, have in the main been very favorably received and widely adopted. From personal experience I know they are leading to a great improvement in the working conditions of roentgen-ray operators in Great Britain and, thanks to the co-operation of the manufacturers, have influenced beneficially the design of much British made apparatus. Similar recommendations have since been made in a

number of other countries,* and a considerable literature has resulted: over 120 papers have, I find, been published on the physics of protection alone. At a discussion at the First International Congress of Radiology held in London in 1925 I ventured to suggest the desirability of international agreement on, at any rate, the main questions of protection. The proposal was adopted and it is hoped that the matter will reach finality at the Second International Congress at Stockholm next year.

It should be understood that there has been no question of legislation in England in this matter. The Ministry of Health and the Ministry of Pensions gave the recommendations their support, and the Home Office consulted the committee on the question of including roentgen-ray dermatitis in the schedule under the Workmen's Compensation Act, a step which was ultimately taken in 1924.

It will not, I think, be without interest if I refer to some of the main points that guided the English Protection Committee in framing its recommendations, more particularly as regards roentgen rays.

A scheme of roentgen-ray protection which rests on a sound physical and biological basis involves:

(*a*) Measuring under specified conditions the intensity of roentgen rays in terms of a specifiable and reproducible physical standard expressed, if possible, in absolute units.

(*b*) Establishing a maximum tolerance dose in terms of a specifiable and reproducible biological standard and, if possible, expressing this biological standard in physical units.

(*c*) Establishing reliable figures for the transmission of roentgen rays of specified quality by lead and other absorbents.

(*d*) Calculating the thickness of absorbent necessary to reduce the intensity of a given beam of roentgen rays to that corresponding to the tolerance dose at some specified point.

The Committee was first confronted with the fact that (in 1921) there was no generally agreed standard of roentgen-ray intensity, nor an accepted method of measurement. That is, in fact, still the position, but we hope this situation also will be met at Stockholm next year. The consequential difficulty of specifying a safe intensity is aggravated by lack of agreement on what is a maximum tolerance dose and what relation it bears to the biological standard selected. For want of a better, the biological standard selected is the erythema dose (H.E.D.; or unit skin dose) which, however, is of variable and uncertain magnitude both biologically and physically. Moreover, while there is a consensus of opinion as to the cumulative biological effect of the rays and also as to the enhanced effect of a single dose as compared with that of the same dose when divided, the questions of the exact extent to which the effect of the divided dose is influenced by the magnitude of each fractional dose and the time interval between the fractional doses, also remain to be settled. Then, too, there is the problem of whether the biological effect is selective or not as regards wave length. Furthermore, the vexed question of idiosyncrasy to roentgen rays, whether acquired or congenital, has to be taken into account. Some radiologists hold the view that it is very exceptional, but Sir Humphry Rolleston,[24] in his Mackenzie Davidson Lecture given in London last June concludes that, while examples of acquired sensitiveness to radiations appear to be rare, "it would appear to be impossible to deny the occurrence of an inborn hypersensitiveness to radiations though extreme degrees may be very unusual."

In the light of the above considerations, the protective values recommended had necessarily to be framed less from the biological aspect than from the point of view of physical measurements and the accumulated experiences of a considerable number of older workers. It was obvious that the protective values selected would have to be in the nature of a compromise,

* So far as I am aware, the following committees have been appointed in different countries to deal with the question of protection:—

England.	The X-Ray and Radium Protection Committee.
United States.	The Safety Committee of the American Roentgen Ray Society.
Germany.	Die Deutsche Roentgengesellschaft.
Norway.	De Norsk Forening for Medicinisk Radiologi.
Russia.	The Radiological Congress of the Soviet Federation.
Holland.	The Protection Committee of the Board of Health.

Austria has legalized certain protective measures, and in Sweden and other Northern European countries the English recommendations have been largely adopted.

as considerations of weight and cost would preclude any attempt at stopping the rays virtually completely. Some small amount of radiation is bound to reach the operator, particularly during screening, but this should be made so small as to be innocuous.

It was, of course, realized that the precautions should be more comprehensive in a busy roentgen-ray department than in, say, a small country hospital where only occasional use is made of the apparatus, but it was felt that, if it could be devised, a very simple cut-and-dried scheme of protection, which could be easily understood and worked to, would be more generally acceptable than a "graded" system based wholly on working conditions. Furthermore, the demands on an apparatus normally tend to increase as time goes on and, unless there is close supervision, the resulting liability to misinterpretation and misuse, particularly in small isolated hospitals, might stultify the very object of the recommendations. Moreover, in large hospitals and particularly in factories using roentgen rays industrially, installations are not at all unlikely to be operated by men with little experience or knowledge. The Committee accordingly took the view that the recommendations should seek to ensure adequate protection on an installation, no matter what the conditions. As Rolleston[24] remarks: "It is important that the recommendations for protection should be based on the principle of absolute safety and so err, if they do so at all, on the side of excess."

At an early stage in its deliberations, the Protection Committee approached the National Physical Laboratory (that is, the British Bureau of Standards) and invited its close co-operation. In response, the Laboratory agreed to test protective materials and protective devices and to inspect and report on roentgen-ray departments of hospitals, etc., from the point of view of the Committee's recommendations. I may add that the Laboratory does not attempt to exercise discretionary powers in such work, but simply states in its reports whether or not the recommendations are complied with.

During the last few years over a hundred hospitals have been so inspected by my Department of the Laboratory, and many hundreds of protective materials and devices have been tested. In some cases we have been called in at several stages in the construction of a new roentgen-ray department, and the carrying out of the Committee's recommendations has thus been ensured from first to last. It may be added that the standing of the Laboratory and its impartial position as a Government institution have proved of peculiar assistance in this inspecting work. It has, for instance, been a matter of interest to us to notice how often our reports have been instrumental in influencing a situation and so assisting a hospital radiologist to obtain the new roentgen-ray department or the new equipment or the added protection he was only too well aware he sorely needed, but had not hitherto been able to get for some good reason from his governing body. That is, I think, an important aspect of the Protection Committee's work.

And now, perhaps, you will allow me to refer to a few of the main recommendations.

PROTECTION

As regards protection, the simplest and most economical plan is to place the roentgen-ray tube within a tube box or shield which is as small as the design of tube will permit and which affords protection in all directions, except, of course, for a suitable working aperture. Supplementary protection for the operator and others in the vicinity may be provided, if necessary, by the walls of the room or by some alternative scheme.

As to the amount of protection, the Protection Committee took the view that the exciting voltage on the roentgen-ray tube was the most weighty factor on which to build a simple scheme of protective values based on the degree of absorption of different qualities of roentgen rays (Fig. 14). Accordingly two main groups of rays were first legislated for: (1) those generated by peak voltages under 100 kv. (covering the bulk of diagnostic work and superficial treatment); and (2) those generated by peak voltages exceeding 100 kv.

Since then these groups have been subdivided and the following protective values

expressed in terms of the equivalent thickness of lead (which is adopted as the standard of reference) are now recommended for the tube box:

Roentgen Rays Generated by Peak Voltages	Minimum Lead Equivalent
Not exceeding 70 kv.	1.5 mm.
Not exceeding 100 kv.	2.0 mm.
Not exceeding 150 kv.	3.0 mm.
Not exceeding 200 kv.	4.0 mm.

In addition, recommendations are made for protection of the operator against scattered radiation, the magnitude of which, particularly close to the patient, is often underrated. The above protective values are equally applicable to the protective glass of fluorescent screens, in view of the fact that, although screening examinations will naturally be conducted as rapidly as possible with minimum apertures, the operator is compelled to work in the direct beam, usually in close proximity to the roentgen-ray tube. In all other work the operator will naturally seek as great a distance as possible in as favorable a direction as the conditions permit. As regards protective gloves, they should afford protection both back and front, and the 0.5 mm. lead equivalent suggested should not lead to undue loss of suppleness.

While in some quarters it is held that the amount of protection recommended by the Committee is somewhat inadequate, particularly at high voltages, on the other hand, there are those who complain that it leads to heavy, unwieldy and cumbersome apparatus, to which the answer is that in the great majority of cases such difficulties are avoided by proper design. For example, the stability, the delicacy of control and freedom of movement which are secured with a big gun or large astronomical telescope leave nothing to be desired; and already many roentgen-ray manufacturers have shown that the difficulties complained of are surmountable by designs which are not unduly costly.

It may here be added that such quantitative biological evidence as has been advanced since the recommendations were drafted is not unfavorable to the Committee's suggested protective values. Steps should be taken to correlate the experiences of all the older workers while they are still with us, for it must be recognized that as yet the evidence in question is based on restricted statistical and biological data. For example, Mutscheller[25] "from a limited number of typical examples" argues that the tolerance dose for an operator should not exceed $\frac{1}{100}$ of an erythema dose every thirty working days; that is, $\frac{1}{1000}$ of an erythema dose every three working days. He further refers to a simple expression, though one of admittedly

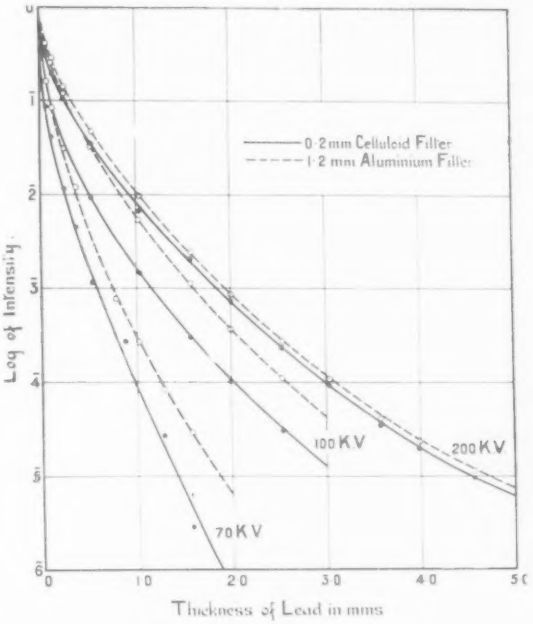


FIG. 14.

doubtful validity, for the intensity of a roentgen-ray beam, which, written in the form

$$\frac{\text{milliamperes} \times \text{minutes}}{25\ (\text{distance in feet})^2}$$

gives, obviously only approximately, the number of erythema doses received at a given distance along the direct beam from a roentgen-ray tube. We can then calculate the amount of lead necessary to reduce this intensity to the tolerance dose.

Glocker and Kaupp[26] adopt Mutscheller's figures for the tolerance dose and incidentally conclude that the fluorescence which can just be seen on a screen in a completely dark room by a well-rested

eye of good acuity corresponds approximately to the tolerance dose. Alternatively, they state, such a dose will only occasion barely visible blackening of a duplitized film after about an hour's exposure.

Sievert[27] adopts $\frac{1}{10}$ erythema dose a year as a safe dose, i.e., $\frac{1}{1000}$ erythema dose every three working days.

Solomon[28] expresses the opinion that an erythema dose spread over a time of the order of a year loses all biological significance. On the basis of a 300 working-day year this corresponds to a tolerance dose of $\frac{1}{1000}$ erythema dose in 0.3 day.

The Protection Committee of the Dutch Board of Health recommended in May, 1926, that the operator should not receive an erythema dose within 90,000 hours: that is $\frac{1}{1000}$ of an erythema dose in fifteen days (of six working hours). The corresponding period suggested for the casual occupants of adjacent rooms is 1.5 days.

Barclay in some unpublished work, which he kindly permits me to quote, has recently suggested (1927), on the basis of two cases, a figure of 0.07×10^{-3} erythema dose per day for the limit of safety, that is, $\frac{1}{1000}$ of an erythema dose in fourteen working days.

Thus we have the following estimates for the tolerance dose for the operator:

	$\frac{1}{1000}$ Erythema Dose in
Mutscheller	3 days
Sievert	3 days
Solomon	0.3 days
Dutch Board of Health	15 days
Barclay	14 days

We may take a round figure of ten days as a mean value, which may be utilized in 3 typical cases, for a fairly busy roentgen-ray department. In the absence of experimental data, we will for what it is worth make use of the formula on p. 415 to derive an approximate estimate of the intensity of the roentgen rays from a bulb in erythema units.

If allowance is made for scattered rays, these respective thicknesses will be increased to, say, 1¾, 3 and 4 mm. or even more. It thus appears that, as far as the evidence goes, the protective values recommended by the English Protection Committee are reasonable and practical. It may be added that Behnken,[29] of the German Reichsanstalt, in a discussion on International Protective Measures in Berlin in 1925 expressed the same opinion from somewhat analogous reasoning.

	Roentgenography	Screening	Deep Therapy
Peak voltage on tube	100 kv.	100 kv.	200 kv.
Current	25 ma.	4 ma.	4 ma.
Total exposure per day	5 min.	1 hour	8 hours
Distance of operator from target of tube	5 feet	2 feet	10 feet
No. of erythema doses in 10 days with no protection	2	24	8
To reduce to maximum tolerance dose divide therefore by	2,000	24,000	8,000
Minimum thickness of lead thus required (no scattering). See Table I	1.5 mm.	2.5 mm.	3 mm.

MEASUREMENT OF PROTECTIVE VALUES

During the last few years measurements have been undertaken at the National Physical Laboratory* on the absorption of roentgen rays by a variety of protective materials including metals, plasters, bricks, concrete, etc. Transformer currents with peak voltages of 50, 100, 150 and 200 kv. and materials of thicknesses up to an equivalent of 3–4 mm. of lead, were normally employed. The cross section of the roentgen-ray beam and the area over which the transmitted energy was measured were each quite small (except for the more heterogeneous materials where a rather wider beam was employed), so that the results approximate to true absorption figures. If, on occasion, the effect of scattered radiation was also measured, this is stated. The results for each material are shown graphically and the values derived from the smooth curves are set out in Tables I and II.

PROTECTIVE METALS AND LEAD COMPOUNDS

Figure 14 and Table I show the absorption of roentgen rays by metallic lead with a filter of 0.2 mm. of celluloid (that is, virtually no filter) and also with a filter of 1.2 mm. of aluminum. It will be noted that a reduction of intensity to 1/10,000 occurs with a 2 mm. screen at 100 kv., as also with a 3 mm. screen at 200 kv.

The absorption curves for the remaining materials are all referred to lead as a standard, the results being given in Table

* Some earlier results are given in a paper by Kaye and Owen.[3]

TABLE I

TRANSMISSION OF ROENTGEN RAYS BY LEAD

Thickness of Lead, mm.	70 Kv.		100 Kv.		200 Kv.	
	X-Rays First Filtered by		X-Rays First Filtered by		X-Rays First Filtered by	
	0.2 Mm. Celluloid	1.2 Mm. Aluminum	0.2 Mm. Celluloid	1.2 Mm. Aluminum	0.2 Mm. Celluloid	1.2 Mm. Aluminum
0	1	1	1	1	1	1
0.2	0.0182	0.0407	0.0502	0.154	0.125	0.180
0.4	0.00325	0.00748	0.0175	0.0573	0.0533	0.0748
0.6	0.000805	0.00213	0.00741	0.0252	0.0264	0.0361
0.8	0.000257	0.000741	0.00343	0.0123	0.0141	0.0194
1.0	0.0000944	0.000294	0.00170	00.612	0.00791	0.0109
1.2	0.0000391	0.000126	0.000891	0.00321	0.00470	0.00632
1.4	0.0000177	0.0000573	0.000491	0.00177	0.00286	0.00373
1.6	0.00000851	0.0000271	0.000282	0.00103	0.00179	0.00225
1.8	0.00000430	0.0000136	0.000169	0.000617	0.00114	0.00140
2.0	0.00000227	0.00000708	0.000103	0.000380	0.000736	0.000883
2.5	.....	.....	0.0000336	0.000124	0.000255	0.000294
3.0	.....	.....	0.0000119	0.0000445	0.0000957	0.000111
3.5	.....	.....	.....	.....	0.0000401	0.0000475
4.0	.....	.....	.....	.....	0.0000196	0.0000234
4.5	.....	.....	.....	.....	0.0000108	0.0000128
5.0	.....	.....	.....	.....	0.00000631	0.00000748
5.5	.....	.....	.....	.....	0.00000394	0.00000462

11. We may conveniently speak of either the lead equivalent or the lead coefficient of a material. These may be defined as follows:

The *lead equivalent* of a material of given thickness is the thickness of lead which has the same absorptive power as the given thickness of material.

The *lead coefficient* of a material is the thickness of lead which has the same absorptive power as unit thickness of the material. The coefficient is often expressed as a percentage.

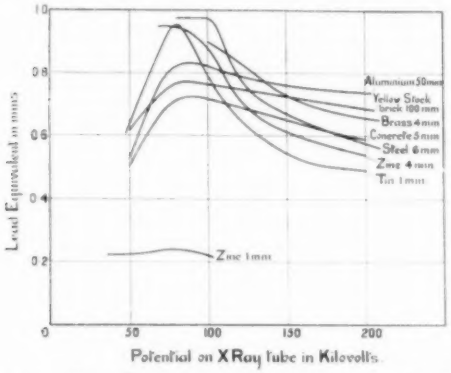
The various results show that, as would be anticipated, the lead equivalents of protective materials depending only on lead or lead salts as absorbents, are proportional to the thickness and do not vary with the exciting voltage. On the other hand, in the case of materials depending on elements lighter than lead as absorbents, it is found that (*a*) the lead equivalents vary with the voltage, reaching a maximum at 80–110 kv.; and (*b*) the lead equivalents are not in all cases proportional to the thickness, thinner materials usually being relatively more absorbent than thick, the divergence from a linear relation being more pronounced at the higher voltages. In other words, short waves are cut off more effectively by lead than by lighter elements.

The maximum lead equivalent is found to occur at about 90 kv. for all the materials tested, namely, aluminum, steel, brass, zinc, tin, barium sulphate, bricks and concrete (Fig. 15). We are led to look for a common cause in the K discontinuity of lead which occurs at about this voltage.

Figure 16 shows the lead equivalent curves for steel, and Figure 17 those for brass of density 8.4, the latter curves being sufficiently representative, for many purposes, of both copper and zinc which are largely used for filters.

Figure 18 incorporates the measurements during the last six years at the National Physical Laboratory of the percentage lead coefficients and densities of several hundred samples of lead glass derived from many sources. The values are the same whether the exciting peak voltage is 100 or 200 kv. The PbO contents range from about 30 per cent to 60 per cent by weight, while the lead coefficients lie between 13 and 26 per cent. Such glasses can all be

made clear and virtually colorless. It will be seen that, in general, there is a linear relationship between the density and the lead coefficient of lead glass as manufactured commercially, and we infer that, from a protection point of view, the lead

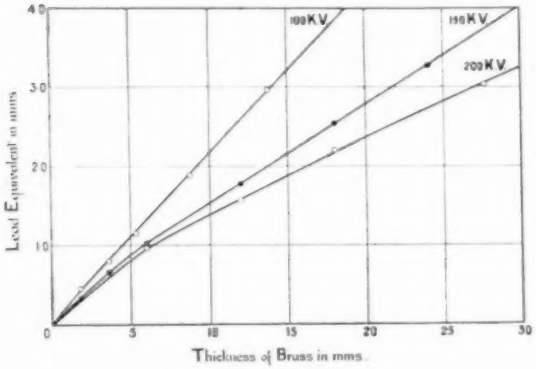


Variation of Lead Equivalent of different materials with voltage

FIG. 15.

content dominates the other elements present. The mean straight line of Figure 18 corresponds approximately to the relation:

$$\begin{pmatrix}\text{percentage lead}\\ \text{coefficient}\end{pmatrix} = 10\,(\text{density}) - 20$$

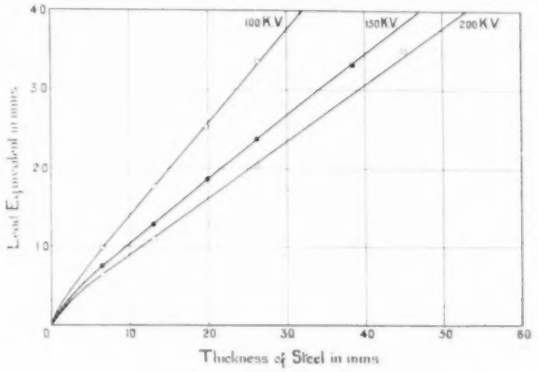


Lead Equivalent of Brass

FIG. 17.

which gives us a very simple means of ascertaining the lead coefficients of glasses which owe their protective properties to their lead content. If the line is produced, it passes close to the value for metallic lead (density 11.4).

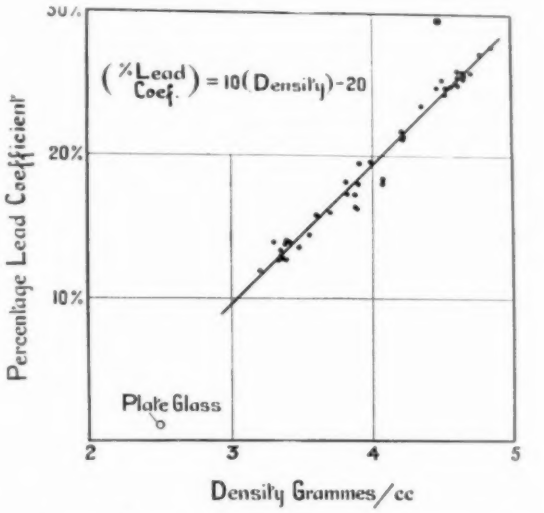
Two points are shown in Figure 18 which are well off the line. One refers to ordinary plate glass of density 2.5, which had only a small proportion of lead in it. The other point refers to a clear slightly yellowish glass of specific gravity 4.5, which proved to have the exceptionally high lead coefficient of nearly 30 per cent. Moreover, the high protective value was evidently



Lead Equivalent of Steel

FIG. 16.

not due solely to the lead present, or the point would have lain on the curve. Chemical analysis showed that the glass contained about 45 per cent PbO and 17 per cent BaO, the baryta contributing of course to the protective value. As a



Lead Equivalent and Density of Lead Glass.

FIG. 18.

consequence of the high baryta content, the lead coefficient, unlike that of the normal lead glasses, was affected by the

voltage, the figure dropping from about 30 per cent to 26 per cent as the peak voltage was raised from 100 to 200 kv.

Figure 19 gives similar results for lead rubber.* The straight line drawn is the average for several hundred samples from a variety of sources. The lead coefficients which are the same for 100 kv. and 200 kv. peak, range between about 20 and 45 per cent and the specific gravities between about 3 and 6. Values for pure rubber are included, as well as an observation on a sample of lead rubber, with a specific gravity of 7 and a lead coefficient as high as 56 per cent. This rubber was, however, so heavily loaded as to be brittle and devoid of insulating properties. The samples with the lower lead coefficients do not lie so well on the line as the denser samples. The mean straight line, which if produced passes through the value for metallic lead (density 11.4), leads to the approximate relation for lead rubber:

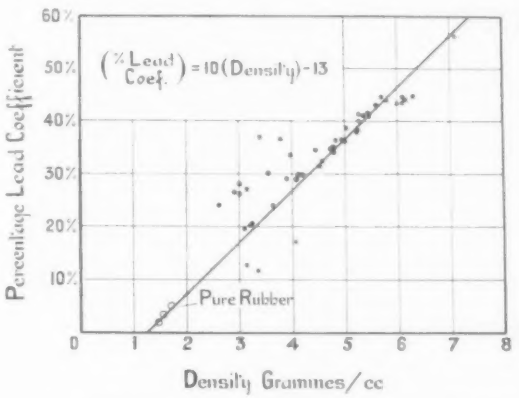
$$\begin{pmatrix}\text{Percentage lead}\\ \text{coefficient}\end{pmatrix} = 10\ (\text{density}) - 13$$

PROTECTIVE SLABS AND PLASTERS

The high cost of lead has led to the introduction of various types of protective slabs and plasters consisting of a compound of some heavy metal, such as galena, lead oxide or barium sulphate, together with some binding material such as Portland cement, gypsum (plaster of Paris), magnesium oxychloride, glue, shellac, bakelite, paxolin, wax, or sodium silicate. Sometimes the absorbent is simply packed into hollow walls; for example, galena was so used in the Radium Institute in Paris.

We have experimented at different times with most of these materials, the majority of which are ruled out on the score of cost or for other reasons, such as difficulty of application, or cracking on setting. Portland cement will not set when admixed with galena or the oxides of lead; magnesium oxychloride, plaster of Paris or glue may, however, be used as binders. Litharge also sets with glycerine, the mixture forming a lute which has long been known. Red lead is poisonous and, in common with litharge and galena, does not compete with metallic lead on the score of cost.

Of the various protective plasters and slabs, those which rest on the use of barium sulphate have found extensive commercial application. Lorey and Kämpe[31] in Germany in 1919 appear to have been the first to manufacture and use building material containing barytes. They were followed by H. Béclère, Chevrotier and Lumière,[32] who in 1922 devised bricks containing 66 per cent by weight of barytes.



Lead Equivalent and Density of Lead Rubber.

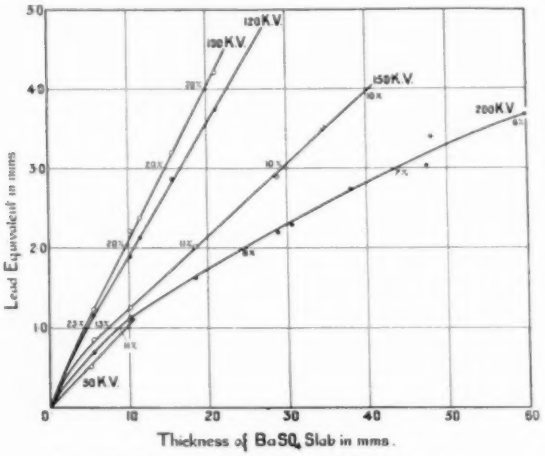
FIG. 19.

Since then barium sulphate plasters and slabs have been used in a good many hospitals in various countries. For example, a plaster containing 33 per cent of $BaSO_4$ (by volume) was used at the Manchester Royal Infirmary in 1922 and one of 40 per cent at the Edinburgh Royal Infirmary in 1925. The highest proportion of barium sulphate that will make a satisfactory plaster with the Portland cement binder that is commonly used appears to be approximately 75 per cent by volume (about 85 per cent by weight). The well-known Kämpe-Lorey slabs have approximately this composition. About two-thirds of the barytes should be rather coarse grained to secure good binding qualities with the cement. The remainder should be finely ground to assist in securing uniformity of protection, for which of course good mixing is also essential. The

* Martin in 1904 in England, and Meisel in 1906 in Germany appear to have been the first to file patent specifications in connection with the incorporation of lead or other metals into rubber.

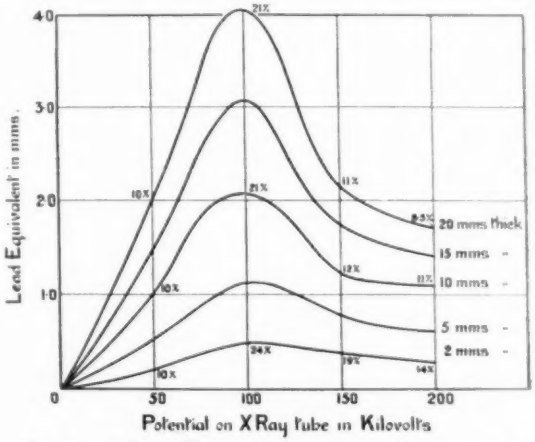
barium plasters are equally suitable for wood or metal laths.

Figure 20 expresses the relationship between lead equivalent and thickness of barytes slab (75 per cent $BaSO_4$ by volume) for voltages between 50 kv. and 200 kv.* For all practical purposes we may take it that for voltages up to 120 kv. the lead equivalent is proportional to the thickness, but at 200 kv. the greater thicknesses are relatively less effective than the smaller



Lead Equivalent of 75% (by vol.) $BaSO_4$ Slab.

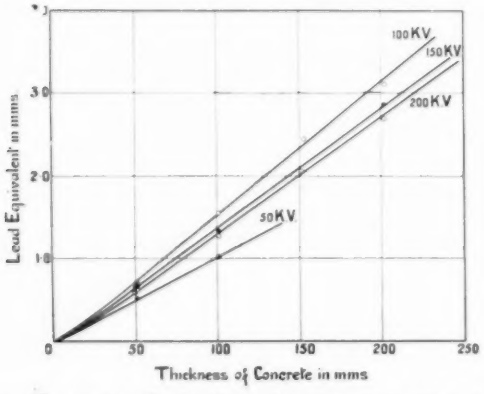
FIG. 20.



Variation of Lead Equivalent of different thicknesses of 75% Barium Sulphate Slabs with different voltages.

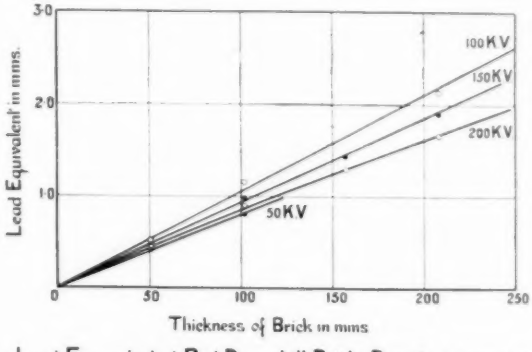
FIG. 21.

doubtless owing to the increased scattering, e.g., at 200 kv. the lead equivalent of a 10 mm. slab is 1.1 mm; of a 60 mm. slab 3.7 mm. We see, too, that the lead equivalent curve is steepest at 100 kv., the values being less for voltages both higher and lower than this, e.g., the lead equivalents for a 10 mm. slab are 1 mm. at 50 kv., 2.1 mm. at 100 kv.; and 1.1 mm. at 200 kv. This maximum value at 100 kv. is also clearly displayed in Figure 21, the explanation doubtless being, as already remarked, the existence of the K discontinuity of lead at about 90 kv. emphasized by that of barium at about 40 kv. The percentage lead coefficients are indicated on the curves of Figures 20 and 21 at various points.



Lead Equivalent of Concrete (4 parts stone chippings, 2 parts washed sand, 1 part cement) Density 2·1 grm/cc

FIG. 22.



Lead Equivalent of Red Daneshill Brick Density 1·9 grm/cc

FIG. 23.

In Table II the equivalent thickness of barium plaster should be increased by an amount up to 40 per cent if scattered radiation is to be allowed for. It may be noted that of two walls affording protection equivalent to 3 mm. of lead, one of

* A preliminary account of this was given in a paper before the First International Congress of Radiology in 1925. See Kaye.[33]

TABLE II
ROENTGEN-RAY PROTECTIVE MATERIALS

Material	Mean Density	Lead Equivalent	Equivalent Thickness of Material in Mm.			
			50 Kv.	100 Kv.	150 Kv.	200 Kv.
	Gm. /c.c.	Mm.	Mm.	Mm.	Mm.	Mm.
Aluminum	2.7	1	96	60	65	70
		2	.....	120	130	140
		3	.....	180	195	210
Brass	8.4	1	6.5	4.5	6.0	6.5
		2	.....	9	13.5	16
		3	.....	14	21.5	27
		4	.....	19	30	40
Steel	7.8	1	11.5	6.5	9.5	11.5
		2	.....	15	21.5	25
		3	.....	23.5	34	39
		4	.....	32	47	53
Lead Glass	4.6 to 3.4	1	4 to 7.5			
		2	8 to 15			
		3	12 to 22.5			
		4	16 to 30			
Lead Rubber	5.8 to 3.3	1	2 to 5			
		2	4 to 10			
		3	6 to 15			
		4	8 to 20			
Barium Plaster	3.5	1	10	4	7.5	9
2 parts coarse $BaSO_4$	...	2	.....	9	18	25
1 part fine $BaSO_4$	....	3	.....	14.5	29	43
1 part Portland cement	...	4	.....	20	41	65
Concrete	2.1	1	100	70	75	80
4 parts Stone Chippings	...	2	.....	130	145	150
2 parts Sand	...	3	.....	190	215	220
1 part Cement						
Concrete	1.5	1	135	100	105	110
4 parts Clinker	...	2	.....	200	210	220
1 part Cement						
Concrete	2.1	1	110	70	80	85
4 parts Granite	....	2	.....	145	160	170
1 part Cement	...	3	.....	215	240	260
Coke Breeze	1.2	1	200	110	.....	130
		2	.....	220	.....	270
Daneshill Brick (red)	1.9	1	125	100	110	120
		2	.....	200	220	250
Stock Brick (yellow)	1.5	1	170	130	150	170
		2	.....	280	350	450

metallic lead (density 11.4), the other of barium plaster (mean density 3.5), the latter will weigh about half as much again for 100 kv., and between 4 and 5 times as much for 200 kv. These ratios will be increased if allowance is made for scattering and the possibility of faulty mixing.

Figures 22, 23 and 24 give corresponding curves for a concrete and two different kinds of brick. The various thicknesses given in Table II should be increased by an amount up to about 30 per cent if scattering is allowed for.

ELECTRICAL PRECAUTIONS

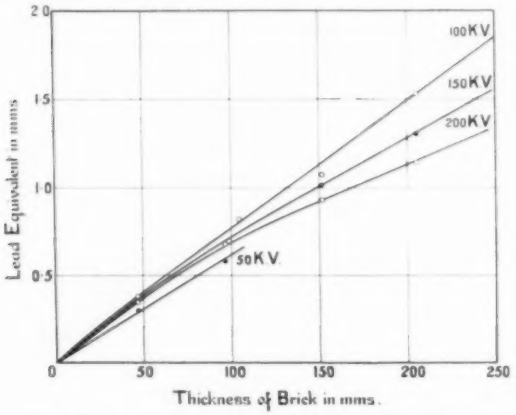
In view of the accidents which have occurred in the past, the Protection Committee was led to stress the dangers of high voltages, particularly with modern high-powered constant-potential outfits which utilize large condensers. Such dangers are minimized by the use of large and lofty rooms, the floors of which are covered with insulating material such as cork or rubber. Coronaless tubing at a height of not less than 9 ft. is recommended for the overhead conductors. The importance of effectively grounding all metal parts of an apparatus

is not always realized. Other more detailed matters are also dealt with in the report.

Incidentally, there are many advantages from the point of view of noise, as well as ventilation, in mounting rotating machinery, and as much as possible of the high tension equipment, in an adjacent room. Switching on roentgen rays should be as devoid of incident for the patient as turning on an electric lamp.

VENTILATION, ETC.

The question of adequate ventilation has assumed an importance second only to that



Lead Equivalent of Yellow Stock Brick Density 1·5 grm/cc.

FIG. 24.

of protection, for the gases generated by high tension roentgen-ray equipment are responsible for much of the lassitude, debility, headaches and anemia experienced by many workers. Rooms should be spacious and lofty: the minimum area may well be taken as about 300 sq. ft. with a height not less than 11 ft.

But, as we have repeatedly noticed in our inspection work, large airy rooms are not in themselves sufficient, for it is difficult to make a roentgen-ray outfit completely coronaless, particularly at high voltages, and the high tension discharge speedily vitiates the air to an extent which calls for very efficient ventilating arrangements. Natural ventilation, even if ordinarily good, is rarely adequate for roentgen-ray rooms and moreover is apt to be unsatisfactory on windy, stagnant or very cold days. In any case, such ventilation is usually put out of action if the room is darkened. Artificial ventilation is practically always necessary for roentgen-ray and dark rooms and control cubicles. In general, exhaust ventilation is to be preferred to pressure ventilation. A general ventilating scheme with ducts leading from the different rooms to a main air channel and a common fan is often likely to have its even distribution disarranged by an untoward opening of doors or windows, with the result that one room may get more than its share of fresh air at the expense of other rooms. If the conditions permit the windows to be opened widely so that fresh air may enter in abundance, this is to be encouraged but, to avoid the possibility of interfering with the ventilation of neighboring rooms, it may be better to fit each room with its independent ventilating arrangements. The initial outlay and running costs will of course, be heavier.

In our experience the most effective and reliable form of ventilation for roentgen-ray and dark rooms is to provide each room with its own suction fan or fans, each fan to have its own outlet and to be mounted so as to extract air from near the ceiling, fresh air entering from without by inlets placed 2 or 3 feet from the floor and so placed as to secure crosswise ventilation. By this means the operators are working at a level where the air is freshest and less admixed with vitiated air. A number of distributed inlets should normally be provided and the area of both inlets and outlet should be ample, the total area of the former being several times that of the latter. The incoming air should, if necessary, be warmed by radiators or the like in cold or damp weather. Cooling would be equally desirable in hot weather if it were possible. As a rule, we do not find roentgen-ray rooms which have the ventilating arrangements reversed—i.e., with the suction outlet at low level and the inlets near the ceiling—to be so satisfactory. This latter arrangement is sometimes advocated in view of the fact that the deleterious gases produced by the high-tension discharge are somewhat heavier than air; but it is contrary to theory to anticipate that in such circumstances gravity would exercise any appreciable influence on the proportions

of the gases present. On the contrary, the first tendency of the gases in question will usually be to rise rather than fall, owing to the warmth which may accompany their generation. This applies also to the products of respiration, and experience suggests that the direction of flow of the incoming air should also be upwards.

The enclosed-propeller type of fan is usually satisfactory. It should be quiet in running. Frequently the fan installed is under powered; its capacity should be such as to scavenge and renew completely the air throughout a room in about 5 or 6 minutes. This should be borne in mind when heating arrangements are being planned. A perceptible movement of the air, if it is not too cold, is pleasant and beneficial, provided the speed is not such as to cause draughts. According to the pamphlet on "Ventilation of Factories and Workshops" issued by the Home Office in England, the speed of the incoming air should not normally exceed 250 feet per minute. Incidentally, in some rooms both inlets and outlet may require to be light trapped, and the outlet may need to be shielded externally if the prevailing winds are unfavorable.

As regards the temperature of roentgen-ray departments, the work of Leonard Hill in England and of the U. S. Public Health Service indicates that, on the whole, human activity reaches its height at temperatures in the region of 18°C. or 65°F. It is claimed that, under such conditions, there is least sickness, fewest accidents, metabolism is at its lowest and comfort is at a maximum. A rise of temperature above the optimum is more adverse to activity than a fall.

One of the traditions which dies hard, at any rate in Great Britain, is the placing of roentgen-ray departments in basements. Much, of course, depends on the kind of basement, but, in general, roentgen-ray departments are far better placed at a higher level where, if properly designed and situated, they are sure of such sunshine as occurs, where the natural lighting and ventilation are more likely to be good and where it is more readily possible to open the windows at any time without sacrificing privacy or allowing dust to blow in from the ground level. Few basement sites permit these desiderata. If a building is of several stories, the top floor has much in its favor, as the protection of adjacent floors is simplified.

Top natural lighting is preferred by some workers, but is sometimes troublesome to darken and in our experience does not normally contribute so agreeably to the amenities of a room as do ordinary windows. Such windows, except where other considerations forbid, may well be of generous dimensions with clear glass and low sills so that the operator does not feel "cribbed, cabined and confined," a sensation apt to be fostered when top lighting alone is employed. A sunny aspect is preferable to north lighting which offers no advantages for roentgen-ray rooms.

The roentgen-ray department should be as bright and cheery in its scheme of decoration as any hospital ward. The dark room should be no exception; with good safe lights it is unnecessary to blacken the walls and ceiling for routine work. There should be a standing rule that roentgenographic, screening and developing rooms should be opened up to daylight and fresh air directly they are not in use. To this end, the shutters or dark blinds should be of a quick acting type which are not troublesome to operate. Developing rooms are often much too small: when a new department is being designed, not less than 100 to 150 square feet should be allotted to the dark room, and much more for a large department.

The Committee also made recommendations as to the working hours of whole-time roentgen-ray and radium workers and suggested a seven hour working day, a five day week (Sundays and two half-days off duty) and holidays amounting to a month in a year. The importance of an outdoor life when off duty was urged.

As an illustration of the value of the recommendations, I may cite the new roentgen-ray department at the Royal Infirmary, Edinburgh, probably the largest and finest example of its kind in Europe at the present time. Great care was taken in its design and equipment to conform to the recommendations of the British Protection Committee, and the building was

inspected by the National Physical Laboratory both during erection and on completion. Dr. Woodburn Morison, the head of the department, permits me to quote the following:

"The health of the workers in the new Radiological Department has been excellent, and it is particularly noticeable in the case of the old workers who, for so many years, were working under bad conditions, not only as regards protection from X-radiations, but as regards the light and ventilation of the Department. The case of Mr. W. Law, the senior lay radiographer, is an excellent example. He began work in the old X-ray department of the Edinburgh Royal Infirmary in 1900, at the age of 16. For years his average weight was 9 st. and his health indifferent, except during holidays. He was on active war service from August, 1914 until March 1919, doing no X-ray work and living an open air life. His weight increased during this time to 11 st. 4 lbs. and his health was good. After the war he returned to the old X-ray Department and was working under the old conditions. He gradually lost weight until he reached his old average weight of 9 st. We transferred to the new Radiological Department in August 1926, and since then he has gradually put on weight and at the present time (July 7, 1927) is 11 st. 4 lbs., the weight which was his average during active service. With the increase in weight there has been a very noticeable improvement in his general health.

"I attribute this in the first place to the efficient protection of the apparatus and the building; in the second place to the efficient lighting and ventilation of the whole department; in the third place to the working hours not more than seven per day—Saturday afternoon, Sunday and one half day in the middle of the week off work. Also one month's holiday during the course of the year. It practically amounts to this that we have endeavoured to carry out in full the recommendations of the Protection Committee; not only as regards the protection of the instruments and the building, but what I think is equally important, the recommendations regarding the hours of work and holidays for all those engaged in X-ray work."

Other examples could be adduced, but this I think will serve.

To sum up, the Protection Committee concludes that "the dangers of overexposure to X-rays and radium can be avoided by the provision of efficient protection and suitable working conditions." Radiology is, in fact, no more dangerous, under proper conditions, than scores of other professions. All honor to the pioneers for taking the risks they did in the service of humanity, but it is only too true that those risks need never have been taken had the knowledge been available as it is now. It is not, however, in the interests of roentgenology that new cases of even minor casualties should be allowed to occur in the future through faulty working conditions. Even while I was writing this paper two instances have come to my knowledge of young physicists being badly burned in roentgen-ray spectroscopic work. One of them has already lost a finger. Both accidents were perfectly avoidable. A succession of such casualties is bound to react unfavorably on the public (already a little uneasy), on other branches of the profession and, even more deplorable, on potential entrants to a radiological career. Furthermore, the ignorant, the inexperienced, the indifferent, the irresponsible, the scoffer and the foolhardy should be taught by practice and precept to realize that, apart from their own interests, such casualties are prejudicial to their fellow workers in that they tend to stiffen the backs of the insurance companies who, on both sides of the water, are, I understand, already somewhat disposed to consider roentgen-ray workers as abnormal risks.* We may consider such an attitude as unreasonable, but it is bound to take time to dispel, and it is obviously not only a duty, but good from every point of view that roentgenologists in charge of roentgen-ray departments should all face the situation by allowing no loophole, erring, if needs be, on the side of safety rather than by being content with the bare minimum of protective measures. "He who walks warily walks well," and presently statistics will tell their own tale and produce an unanswerable case.

And now my task draws to its close. There is much besides I would have liked to raise, but time forbids and I would not willingly encroach on the limits of your kindly patience. One final impression. The three phenomena of the differential absorp-

* For example, see Melville.[34]

tion of roentgen rays by various kinds of matter, the biological effects of the rays and the diffraction of the rays by crystalline solids have been turned to account in the arts, sciences and industries in many directions. The diversity of the applications of the roentgen rays has indeed become such that one scarcely envies the task of the future student of the subject. Specialization will become inevitable, as is apparent from the immense literature that has already come into being from the activities of the large body of workers who have been attracted by the various problems to which roentgen rays are being applied whether medical, scientific or technical.

Our knowledge of the ultimate structure of the solid state of matter already owes more to roentgen-ray analysis than to any other means. As to the value of roentgenography to the surgeon, it is surely almost incalculable. On the biological side it would seem that, while wonderful results are achieved from time to time in therapy, progress is somewhat hampered by a number of factors. Quantitative measurements and physical units in which to express them will be bound up with future developments, despite the fact that the physics of such work is apt to be embarrassed by the power of selection and choice exhibited by the living cell. In the opinion of some authorities roentgenology in the future is likely to find its biggest field of development in the science of biophysics;* and closer co-operation between the roentgenologist and the physicist is bound to come.

Finally, I would submit a plea for an effective working understanding between the American and British roentgen-ray societies as to the exchange of literature and information. By such means we shall assist in furthering the development of a science which we are proud to think has exerted no small influence on the progress of civilization.

REFERENCES

1. Thomson, J. J. *Phil. Mag.*, 1926, ii, 674.
2. Compton, A. H., and Hagenow, C. F. A measurement of the polarization of secondary rays. *J. Optical Soc. Am.*, 1924, viii, 487–491.
3. Bishop. *Phys. Rev.*, 1926, xxviii, 625.
4. Barkla. *Phil. Mag.*, 1916, xxxi, 257.
5. Compton. Total reflection of *x*-rays from glass and silver. *Phys. Rev.*, 1922, xx, 84; *Phil. Mag.*, 1923, xlv, 1121.
6. Darwin, C. G. *Phil. Mag.*, 1914, xxvii, 318.
7. Larsson, A. *J. de phys.*, 1925, vi, 229.
8. Kirkpatrick. *Nature*, 1924, cxiii, 98.
9. Doan. *Phil. Mag.*, July, 1927, iv, 100.
10. Prins. *Nature*, August, 1927, cxx, 188.
11. Larsson, A., Siegbahn, and Waller, I. The experimental proof of the refraction of Röntgen rays. *Naturwissenschaften*, 1924, xii, 1212–1213.
12. Davis, Bergen, and Slack, C. M. Measurement of the refraction of *x*-rays in a prism by means of the double *x*-ray spectrometer. *Phys. Rev.*, 1926, xxvii, 18–22.
13. Slack, C. M. The refraction of *x*-rays in prisms of various materials. *Phys. Rev.*, 1926, xxvii, 691–695.
14. Davis and Nardroff. *J. Frankl. Inst.*, 1927, cciv, 29.
15. Bragg, W. L. *Proc. Roy. Soc.*, 1913, lxxxix, 248.
16. Carrara. *N. Cimento*, 1924, i, 107.
17. Compton and Doan. *Proc. Nat. Acad. Sc.*, 1925, xi, 598.
18. Thibaud, J. *Compt. rend. Acad. de sc.*, 1926, clxxxii, 55.
19. Müller, A., and Shearer, Geo. Further *x*-ray measurements of long-chain compounds and a note on their interpretation. *J. Chem. Soc.*, 1923, cxxiii, 3156–3164.
20. Thoraeus, R. *Phil. Mag.*, 1926, i, 312.
21. Dauvillier. *J. de phys.*, 1927, viii, 1.
22. Thibaud, J. Jonction spectrographique du domaine des rayons X à l'ultraviolet à l'aide de réseaux lignés. *Compt. rend. Acad. de sc.*, July 4, 1927, clxxxv, 62–64.
23. Walter. *Ann. de phys.*, 1924, lxxiv, 661; 1924, lxxv, 185.
24. Rolleston, Humphry. On the effects of radiations on patients and radiologists, and on protection. *Brit. M. J.*, July 2, 1927, ii, 9–13.
25. Mutscheller, A. Physical standards of protection against roentgen-ray dangers. Am. J. Roentgenol. & Rad. Therapy, 1925, xiii, 65–70.
26. Glocker, R., and Kaupp, E. Über den Strahlenschutz und die Toleranzdosis. *Strahlentherapie*, 1925, xx, 144–152.
27. Sievert, Rolf M. Einige Untersuchungen über vorrichtungen zum Schutz gegen Röntgenstrahlen. *Acta radiol.*, 1925, iv, 61–75.
28. Solomon. Précis de radiothérapie profonde, 1926.
29. Behnken. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1926, xxxiv (Kongressheft), 182–184.
30. Kaye and Owen. *Proc. Phys. Soc., Lond.*, 1923, xxxv, 33D.
31. Lorey and Kämpe. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1919, xxvi, 335.
32. Béclère, H., Chevrotier, J., and Lumière, H. Nouveau matériel de protection contre les rayons X. *Bull. Acad. de méd.*, 1922, 3. s., lxxxvii, 255–257; also *Bull. et mem. Soc. de chir. de Par.*, 1922, xlviii, 123.
33. Kaye, G. W. C. III. Discussion on *x*-ray and radium protection and appliances. X-ray protective measures. *Brit. J. Radiol.*, April, 1927, xxiii, 155–163.
34. Melville, S. Radiography as it affects assurability of operators. *Lancet*, Feb. 5, 1927, i, 319–320.

* For example, see Rolleston.[24]

THE RELATION OF CHEMICAL, COLLOIDAL AND BIOLOGICAL EFFECTS OF ROENTGEN RAYS OF DIFFERENT WAVE LENGTHS TO THE IONIZATION WHICH THEY PRODUCE IN AIR

II. THE ACTION OF ROENTGEN RAYS ON SOLUTIONS OF FERROSULPHATE IN WATER

BY HUGO FRICKE AND STERNE MORSE

Cleveland Clinic Foundation

CLEVELAND, OHIO

EXPERIMENTAL TECHNIQUE

IN this investigation we have used radiations of a higher degree of homogeneity than those employed in the first part* of these studies. These radiations are defined in Table 1, in which are also given effective

TABLE 1

TRANSFORMER WITH MECHANICAL RECTIFICATION. LITHIUM GLASS TUBE-TUNGSTEN TARGET. POTENTIAL DETERMINED WITH 12.5 CM. SPHERE GAP

I.	Potential	100 kv.
	Current	25 ma.
	Filter	0.60 gr. per sq. cm. tungsten
λ_{eff} by absorption in	Copper	0.204 Å
	Tungsten	0.206 Å
	Platinum	0.205 Å
II.	Potential	43 kv.
	Current	40 ma.
	Filter	0.163 gr. per sq. cm. tin
λ_{eff} by absorption in	Copper	0.519 Å
	Molybdenum	0.489 Å
	Tin	0.519 Å
III.	Potential	28 kv.
	Current	40 ma.
	Filter	0.059 gr. per sq. cm. molybdenum
λ_{eff} by absorption in	Aluminum	0.765 Å
	Molybdenum	0.766 Å

wave lengths as determined by means of different selective filters. It will be seen that for radiation I practically the same effective wave length 0.204 Å is obtained by using either a copper or a tungsten filter. This proves that the spectrum of this radiation is practically wholly on the long side of the critical wave length for tungsten, 0.178 Å. We have not measured the absorption of any filter by which the limit to the side of the long wave lengths can be determined; but since 0.204 Å must represent approximately the center, the spectrum cannot extend over more than a small number of hundredths of an Angström. Of course, the K-lines of tungsten ($K\alpha = 0.21$ Å, $K\beta = 0.18$ Å) form an important part of the spectrum.

For radiation II we conclude similarly that it is composed entirely of wave lengths longer than the critical wave length for tin, 0.423 Å. Since the effective wave length for molybdenum, 0.489 Å, is somewhat shorter than the effective wave length for copper, 0.519 Å, we conclude furthermore that a certain fraction of the spectrum extends beyond the critical wave length for molybdenum, 0.618 Å. We can obtain a higher limit for this fraction $(1 - \partial)$ by the following equations which are based on the assumption, which is true with sufficient approximation, that the coefficient of absorption varies as the third power of the wave length:

$$\text{Cu: } 0.519^3 = \partial\lambda^3_1 + (1 - \partial)\,\lambda^3_2$$

$$\text{Mo } {}^{3}_{4}\text{: } 0.489^3 = \frac{C_L(\text{Mo})}{C_K(\text{Mo})} \cdot \partial\lambda^3_1 + (1 - \partial)\lambda^3_2$$

λ_1 and λ_2 are the effective wave lengths (as determined with copper) of the two parts (∂ and $1 - \partial$) into which the spectrum is divided by the critical wave length of molybdenum. $\frac{C_L(\text{Mo})}{C_K(\text{Mo})}$ is the ratio of the two coefficients of absorption for molybdenum at its critical wave length, which ratio, according to Richtmyer[1] is equal to $\frac{1}{7.5}$. By subtracting these two equations we obtain:

$$1 - \partial = \frac{0.519^3 - 0.489^3}{\left(1 - \frac{1}{7.5}\right)\lambda^3_1} = \frac{0.024}{\lambda^3_1}$$

* Fricke, Hugo, and Petersen, B. W. The relation of chemical, colloidal and biological effects of roentgen rays of different wave lengths to the ionization which they produce in air. I. Action of roentgen rays on solutions of oxyhemoglobin in water. Am. J. Roentgenol. & Rad. Therapy, June, 1927, xvii, 611–620.

Since $\lambda_1 > 0.618$, we have $1 - a < \frac{0.024}{(0.618)^3} = 0.10$. That is, we may conclude that at least 90 per cent of radiation II lies between 0.423 and 0.618A, while the rest is on the long side of 0.618 A.

Finally, in regard to radiation III, it is wholly composed of wave lengths longer than the critical wave length for molybdenum, 0.618 A.

Figure 1 gives the spectra of the three radiations as calculated from the unfiltered spectra and the coefficients of absorption of the filter. We have for this calculation used the spectra determined by Ulrey[2] (for radiations II and III) and by Hull[3] (for radiation I) for the potentials indicated by our spark gap readings. For the range of wave lengths for which we use them, Ulrey's spectra represent the total energy of the rays. The ordinates of his curves are therefore multiplied by the coefficient of absorption of air which we have considered as being proportional to the third power of the wave length, the Compton absorption being negligible. These spectra, of course, only roughly represent the actual spectra of our unfiltered radiations; however, because of the high homogeneity of our radiations, an existing difference will have a comparatively small effect on the accuracy of our calculated spectra, these tending to indicate comparatively too large an amount of hard rays.

Figure 1 gives λ_{eff} values which are calculated graphically from the spectral curves. The agreement with the directly measured λ_{eff} is close enough to indicate that the curves give a very satisfactory representation of our radiations.

Except for a few minor details, our experimental technique for irradiating the solution and determining the dose has been the same as that described in Part I of this report. In all experiments the cells containing the irradiated solution consisted of a piece of glass in which was drilled a hole, which was covered on each side with cover-glasses 0.1 mm. in thickness. These cover-glasses were sealed air-tight with a small amount of vaseline. Cells of different diameters and thicknesses were used, the one most employed having a diameter of 3 cm. and a thickness of 2.5 mm. A focal distance greater than before (up to 20 cm.) was generally used. In some cases we have used a smaller graphite ionization chamber, which has a diameter of only 4 mm. and a volume of about 0.1 c.c. With this chamber and a focal distance of 20 cm. the difference between the roentgen-ray intensities at the chamber and at the cell can be reduced to a few per cent; these conditions are used especially in the determination of the absolute value of the doses necessary to produce a certain chemical effect.

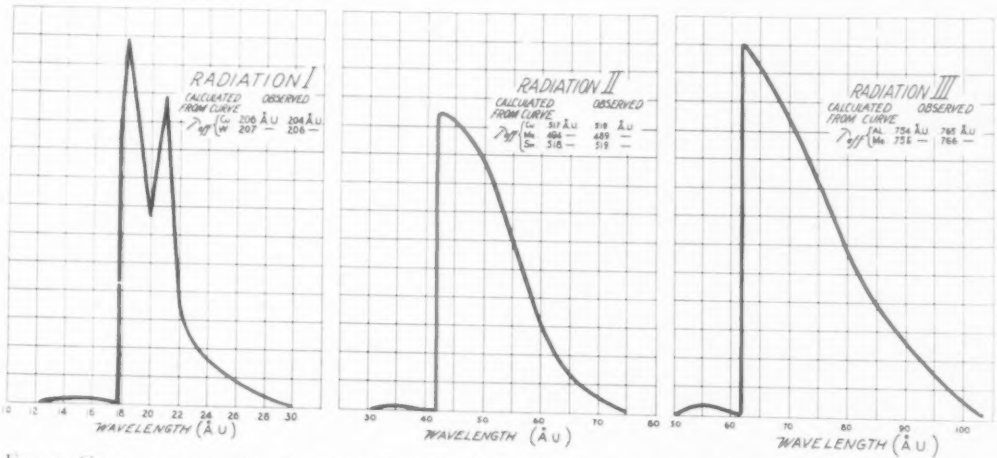


FIG. 1. Curves representing the spectral composition of radiations I, II and III. Intensity in roentgens.

ANALYSIS OF FERROSULPHATE SOLUTION

An acid solution of ferrosulphate is oxidized by roentgen rays to ferrisulphate.

The solution which we have chiefly used in the present experiments is $\frac{m}{1000}$ ferrosulphate in $\frac{8n}{10}$ sulphuric acid. The irradiated solution was analyzed by an electrometric titration, the procedure being to add first a surplus of $\frac{n}{300}$ sodium bichromate and thereafter to titrate back with $\frac{n}{1000}$ ferrosulphate. A diagram of the apparatus used

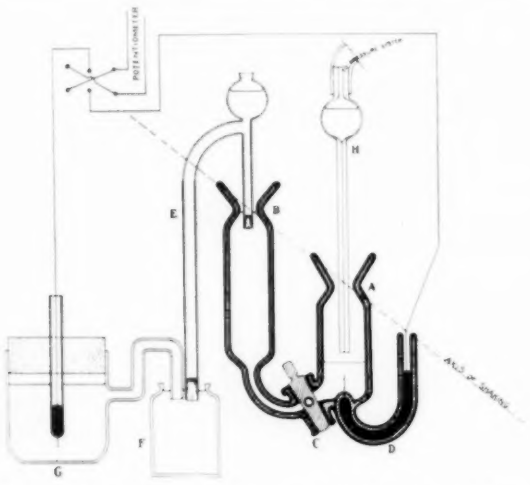


FIG. 2. Apparatus for electrometric titration of ferrosulphate solutions.

in the titration is shown in Figure 2. The solution to be analyzed is placed in the vessel A; its oxidation-reduction potential, recorded by the sealed-in platinum wire, is measured with a potentiometer against the standard electrode G, which consists of a platinum wire dipping into $\frac{n}{10}$ ferrosulphate (in $\frac{8n}{10}$ sulphuric acid) which has been one-half oxidized to ferrisulphate. The liquid chain FEBC between the electrodes, which is sulphuric acid of the same normality $\frac{8n}{10}$ as that used at the electrodes, is designed to prevent leakage of the iron to or from the titration vessel A. The titrating solution is contained in the capillary weight burette H, the upper part of which is connected to a constant air pressure, which can be regulated at will, thereby causing the titrating solution to flow more or less fast or to stop completely. During a titration the flow must be so slow that the platinum wire will always give a true record of the potential of the liquid. During the titration the vessel A is shaken mechanically, as so to produce a very efficient stirring of the analyzed solution. In carrying out an analysis the solution is removed from the radiation cell by a pipette specially designed to prevent evaporation and outflow of the liquid, when laid on the balance. The filled pipette is weighed, the solution poured out into the titration vessel A, and the pipette immediately reweighed. Sodium bichromate is then added to an excess of about 10 per cent and the vessel is shaken, during which operation the potential rises to a maximum value of anywhere between plus 215 and plus 240 millivolts, where it remains constant; this process usually takes about 20 minutes. When the potential is constant, the back titration with ferrosulphate is begun. As an end-point we have chosen plus 150 millivolts. The unirradiated solution is analyzed according to the same technique and the result of the irradiation is expressed as per cent of ferrosulphate oxidized.

The chemicals employed were Merck's "Blue Label" ferrosulphate and Grasselli's "Strictly C. P. Analyzed" sulphuric acid. Dilutions were made with conductivity water.

In the preliminary experiments it was noticed that if immediately after the irradiation a cell in which a solution had been irradiated was filled and irradiated again, the result was different from the result of the first irradiation, this evidently being due to some change produced in the glass during the irradiation. Important as this phenomenon may be, we have not investigated it further but after each irradiation have taken the cell apart and cleaned it thoroughly, thus avoiding this effect.

EXPERIMENTAL RESULTS

As has been mentioned above, the comparison of the different wave lengths has

been made with a solution of $\frac{n}{1000}$ ferrosulphate in $\frac{8n}{10}$ sulphuric acid, the effective atomic number of this solution being the same as that of atmospheric air (7.66). Figure 3 shows that the curve obtained from irradiation with different doses is a straight line.* The dose necessary for complete oxidation is 56.7 K-R. (18°C., 76 cm. pr.), the calculation being based on the slope of this line.

It has already been mentioned that there is evidence that the glass of the cell is not completely indifferent in the reaction. If this is due to a direct action of the rays on the glass, it is to be expected that such an effect would introduce an error in the comparison of different wave lengths. To eliminate this effect we have attempted to use paraffin cells, but the result has not been satisfactory. A series of measurements with glass cells of different thicknesses (1.5 to 6 mm.) shows a slight increase of the effect in the thicker cells, this amounting to less than 1 per cent for radiation I and to a few per cent for radiation II. It is however doubtful whether this increase may not be due to the lack of sufficient exactness in our method for determining the average roentgen-ray intensity in the irradiated liquid, when the thicker cells are used. Because of this uncertainty, the figure for our experimental accuracy cannot be placed below a few per cent, to within which accuracy we may state that the effect on the ferrosulphate solution is independent of the wave length, when the dose is measured in roentgens. A series of representative measurements made with a cell 2.5 mm. thick is given in Table II.

TABLE II

$\frac{1}{1000}$ M. FERROSULPHATE IN 8N SULPHURIC ACID ACID (N_{eff} = 7.66) COMPARISON OF RADIATIONS I (λ_{eff}: 0.204A), II (λ_{eff}: 0.519) AND III (λ_{eff} = 0.765)

Dose. 31.6 K-R (18°C., 76 cm. pr.)

	Concentration of Ferrosulphate in Per Cents of Original Concentration after Irradiation with		
	I	II	III
	44.3	44.1	44.6
	44.7	43.9	44.4
	43.8	44.4	45.0
	44.1	44.0	44.3
Average.....	44.2	44.1	44.6

Cell. 3 cm. diameter, 2.5 mm. thick.

*A series of experiments pertaining to the mechanism of the roentgen-ray action will appear in another place.

With our new radiations we have repeated our former measurements with oxyhemoglobin in a 16.7 per cent potassium chloride solution. We have compared only radiations I and II. We find that the ratio of the effects of these radiations is

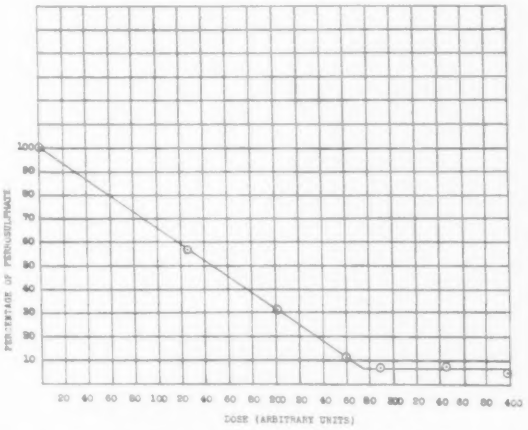


FIG. 3. The action of different doses of roentgen rays on 10^{-3}m ferrosulphate in 0.8n sulphuric acid.

1.31. The effective atomic number of the solution is 10.7, determined by

$$N_{eff}^3 = \frac{\frac{16.7}{74.56}[19^4 + 1^{-4}] + \frac{83.3}{18}[8^4 + 2.1^4]}{\frac{16.7}{74.56}[19 + 1^{-}] + \frac{83.3}{18}[8 + 2]}$$

The ratio of effects may theoretically be expressed by

$$\frac{C_1\lambda_1^3 N_{eff}^3\,(\text{solution}) + C_2(\lambda_1)}{C_1\lambda_1^3 N_{eff}^3(\text{AIR}) + C_2(\lambda_1)} : \frac{C_1\lambda_2^3 N_{eff}^3\,(\text{solution}) + C_2(\lambda_2)}{C_1\lambda_2^3 N_{eff}^3\,(\text{AIR}) + C_2(\lambda_2)} \qquad (1)$$

(compare Part I of this report) in which $C_1\lambda^3 N_{eff}^3$ and $C_2(\lambda)$ are respectively the photo-electric and Compton coefficients of absorption per gram electron. For C_1 we may use: $1.36 \cdot 10^{-2(4)}$. For C_2 we may use the expression derived theoretically by Compton,[5] this making $\lambda_1 = 0.204$ Å; $C_2 = 0.031$ and $\lambda_2 = 0.52$ Å; $C_2 =$

0.016. As a theoretical value of the ratio of effects we thus obtain 1.30. As far as one may conclude from this single case, this agreement indicates that with satisfactory accuracy one may calculate the relative effects of different wave lengths on solutions, the composition of which is not very different from that of water by means of equation (1), using the values of C_1 and C_2 indicated above.

REFERENCES

1. Richtmyer, F. K. The magnitude of the K-absorption discontinuity. *Phys. Rev.*, 1926, xxvii, 1.
2. Ulrey, C. J. An experimental investigation of the energy in the continuous x-ray spectra of certain elements. *Phys. Rev.*, 1918, xi, 401.
3. Hull, A. W. The X-ray Spectrum of Tungsten. General Electric Review, 1916.
4. Allen, S. J. W. The absorption of x-rays of wave length down to .08 Å.U. *Phys. Rev.*, 1926, xxvii, 266.
5. Compton, A. H. A quantum theory of the scattering of x-rays by light elements. *Phys. Rev.*, 1923, xxi, 207.

THE CHEMICAL ACTION OF ROENTGEN RAYS ON DILUTE FERROSULPHATE SOLUTIONS AS A MEASURE OF DOSE

BY HUGO FRICKE AND STERNE MORSE

Cleveland Clinic Foundation

CLEVELAND, OHIO

THE possibility that a chemical reaction quantitatively dependent on roentgen rays might be utilized as a means of standardization of roentgen-ray dosage has been little considered in the recent discussions of this question; nevertheless if such a method could be properly worked out it would seem to meet very well certain of the practical problems involved. The sensitive substance, for example a solution contained in a cell, could be sent from the standard laboratory to the roentgen-ray clinic, where it could be irradiated under actual clinical conditions, and returned to the standard laboratory for analysis.

The principal conditions which must be met in order that a chemical reaction may be of practical value are the following:

1. That the effect of doses of the magnitude used therapeutically can be determined with sufficient accuracy.

2. That the factors on which the reaction depends can be controlled and kept sufficiently constant.

3. That the spontaneous change of both the unirradiated and the irradiated solutions is inappreciably slow over an interval of at least several days.

4. That the sensitive substance does not contain chemical elements, the critical wave lengths of which are within the therapeutic range, in concentrations which are so great as appreciably to influence the roentgen-ray absorption.

One reaction which because of its simplicity appears attractive is the familiar transformation of water into hydrogen and oxygen. With a sufficiently simple technique for making the gas analysis, the employment of this reaction would seem to be practical. The pressure of hydrogen gas produced per 1 kilo-roentgen in 1 c.c. of water is of the order of $\frac{1}{10}$ mm. Hg, which can easily be measured with sufficient accuracy.

Another reaction which may be employed is the oxidation or reduction of a suitable substance in a dilute solution in water. In our study[1] of the chemical effect of roentgen rays of different wave lengths we investigated different reactions of this type and especially the oxidation of ferrosulphate. The most dilute solution used in this investigation was, however, only $\frac{m}{1000}$, the 50 per cent transformation of which requires about 25 K-R. The experiments which we shall describe were made in order to obtain a general idea of the behavior of an $\frac{m}{25{,}000}$ solution of ferro-

sulphate which is oxidized to 50 per cent by a dose of about 1 K-R.

The technique employed is the same as that described in our earlier report.[1] The solution used was an $\frac{m}{25,000}$ ferrosulphate in $\frac{8n}{10}$ sulphuric acid. As we have already shown in the earlier report, the relation between the dose defined by the effect on this solution and that defined by the large ionization chamber is independent of the wave length. The chemicals used were Merck's "Blue Label" ferrosulphate and Grasselli's "Strictly C. P. Analyzed" sulphuric acid. None of these chemicals was purified further. The acid, as we shall see, is not as pure as might be desired. The impurities due to the acid could of course be decreased by using a lower acidity; it was, however, convenient to use the same acidity as that used in our stronger ferrosulphate solutions.

The solution was irradiated in a glass cell 3 cm. in diameter and 4 mm. in thickness. The following details of the titration of the irradiated solution may be given:

The weighed sample of the solution, usually about 3 grams, is placed in the titration vessel and a sufficient amount of $\frac{n}{10,000}$ sodium bichromate added to give a concentration of about $\frac{n}{50,000}$, as reckoned from the whole volume of the solution. The vessel is shaken while the potential is rising to a maximum value of anywhere between plus 215 and plus 240 millivolts,* where it remains constant. Back titration with $\frac{m}{4000}$ ferrosulphate is then started, the pressure on the capillary weight burette being adjusted so that this process will take about twenty minutes, the end-point being taken when the potential is plus 150 millivolts.

The unirradiated $\frac{m}{25,000}$ and the $\frac{m}{4000}$ ferrosulphate solutions are analyzed according to the same technique. The result of an irradiation is expressed as per cent of ferrosulphate transformed.

We have tested two ferrosulphate solutions (III and IV) made up from a strong standard ferrosulphate solution, using the same stock acid. Both solutions are $\frac{m}{25,000}$ on the basis of the dilution ratio. Direct titration with a strong bichromate solution gave 0.0000399n. This titration figure remained constant during the course of the investigation—a period of about ten days.

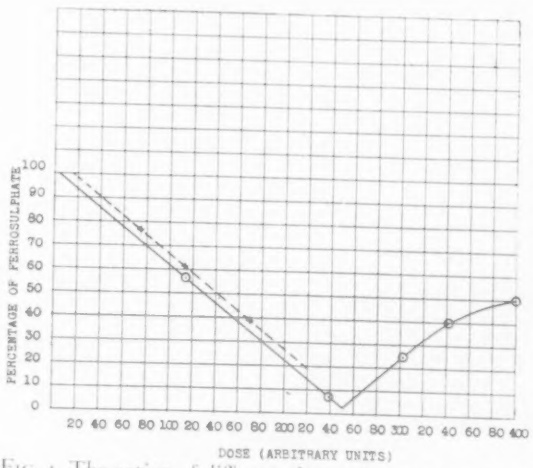


FIG. 1. The action of different doses of roentgen rays on $\frac{m}{25,000}$ ferrosulphate in $\frac{8n}{10}$ sulphuric acid.

The fully drawn curve of Figure 1 shows the action of different doses of roentgen rays on solution III one day after it was prepared. The curve is composed of a straight line and a line the initial slope of which will be seen to correspond very exactly with that of the straight line. It seems that when all the ferro-ions are oxidized a corresponding amount of hydrogen peroxide or of a similar substance accumulates which can be oxidized by sodium bichromate.

The freshly made ferrosulphate solution is somewhat less sensitive than the older solution. The magnitude of the difference will be seen in Figure 1, where the dotted line represents the action on solution III on the day it was made. A new solution behaves as if it contained a non-titratable substance, which uses up the first fraction

* Potentials are compared with an electrode with equal concentrations of ferro- and ferri-ions.

of the roentgen-ray dose, this substance evidently disappearing in a day or two, after which the sensitivity of the solution remains quite constant.

Table 1 gives the results of our different experiments. The dose applied was 1.04 K-R. (18° C., 76 cm.). The following facts are noted: (1) The effect on solutions III and IV is in agreement to within 1 per cent. (2) No systematic change in the effect is observed during the seven days of our observations. (3) There is a slow spontaneous reduction of the irradiated solution, amounting to about 1 per cent per day.

TABLE 1

ACTION OF ROENTGEN RAYS ON $\frac{M}{25,000}$ FERROSULPHATE IN $\frac{8N}{10}$ SULPHURIC ACID. DOSE 1.04 K-R. (76 CM., 18°C.)

Date of Irradiation	Number of Solution	Number of Days after Preparation of Solution: Cell Filled	Cell Irradiated	Cell Analyzed	Ferrosulphate Transformed in Per Cents of Original Concentration
May 30	III	5	5	5	44.61
May 31	III	6	6	6	44.47
June 2	IV	2	2	2	44.86
June 3	IV	2	3	3	44.61
June 7	IV	7	7	7	44.62
June 2	IV	2	2	3	44.60
June 2	IV	2	2	4	42.52
June 2	IV	2	2	6	40.38

The observations were made at room temperature (18–22°C.). We have not directly determined the temperature coefficient of the reaction but it must be quite low.

The dose necessary to oxidize the $\frac{n}{25,000}$ ferrosulphate solution completely is $\frac{1.04}{0.447} = 2.33$ K-R. For an $\frac{m}{1000}$ solution we found 56.7 K-R.[1] as the dose necessary for complete oxidation. The ratio of these doses is 24.4, which differs by only about 2 per cent from the concentration ratio 25.0.

REFERENCES

1. FRICKE, H. The relation of chemical, colloidal and biological effects of roentgen rays of different wave lengths to the ionization which they produce in air.

With Petersen, B. W.,

I. Action of roentgen rays on solutions of oxyhemoglobin in water, AM. J. ROENTGENOL. & RAD. THERAPY, June, 1927, xvii, 611–620.

With Morse, Sterne,

II. The action of roentgen rays on solutions of ferrosulphate in water. AM. J. ROENTGENOL. & RAD. THERAPY, Nov., 1927, xviii, 426–430.

Vol. XVIII, No. 5

SUPERSOFT ROENTGEN RAYS (2 Å) IN DERMATOLOGY*

BY JOSEPH JORDAN ELLER, M.D.

Assistant Professor of Dermatology, New York Post Graduate Medical School and Hospital; Attending Dermatologist Cornell University Medical School and Clinic

NEW YORK CITY

THE rays known as "grenz," supersoft, borderline and infra-roentgen, are roentgen rays of extremely long wave lengths and large absorption coefficients. Their wave lengths average 2 Angström units. These, in comparison with the wave lengths and absorption coefficients of the rays generally employed in superficial roentgen-ray therapy, are of such a low degree of penetrative power that through an average thickness of a human or animal skin there is transmitted a comparatively small percentage of the incident radiation intensity. The property of these very soft roentgen rays to penetrate through known substances, i.e., aluminum, celluloid, etc., is due to the voltage on electrons from which the rays are produced. Therefore by lowering sufficiently the voltage used upon the electrons of a roentgen-ray tube, the wave lengths of the rays and their absorption coefficients increase steadily and when 6 to 10 kv. effective voltage is applied, the coefficients so measured are those of the rays above named, i.e., roentgen rays of 2 Å average wave length.

HISTORICAL

Various workers in the field of roentgenology for the past twenty years have attempted to utilize extremely long wave length roentgen rays for purposes of therapy and even photography. At the Seventh Congress of the German Roentgen Society in 1911, Schultz[1] reported on the application of oversoft roentgen rays from Lindemann tubes used for therapeutic purposes. He found that these rays, which he called "oversoft" roentgen rays, were useful in the treatment of nevus flammeus, basal cell epitheliomas, chronic ulcers and a few other dermatoses. Following large doses, Schultz reported cutaneous reactions which differed somewhat from those presented by roentgen rays ordinarily used. With the "oversoft" rays he found that the incubation time was from one day to six weeks. The ulcerations caused were painless and in most of the cases no atrophy followed. From Schultz' writings it can be concluded that he used a voltage above 10 kv. and possibly even 15 kv., for he measured the penetrability of these rays as being between 1 and 1.5 Wehnelt degrees.

Albers-Schönberg[2] investigating Schultz' work found that the so-called "early reaction," i.e., erythema of the skin, is obtained with a Lindemann glass roentgen-ray tube much more easily than with the ordinary roentgen-ray tube. Albers-Schönberg[3] took photographs of the chest of patients suffering from pulmonary tuberculosis. Thirteen patients were roentgenographed by means of the Lindemann tube. All 13 cases showed distinct early reactions varying from a light pink to a bluish red erythema. This was limited to the chest corresponding exactly with the aperture of the cylinder. The strongest reaction was where the rays were more or less perpendicular. In no case was there any complaint of itching or burning. In 4 cases only was it possible to establish that erythema had appeared during the first five to six hours. In the other 9 cases it could not be determined accurately when the erythema had commenced. Albers-Schönberg felt certain, however, that the erythema had appeared within the first twenty-four hours following irradiation. In all 13 cases this early reaction disappeared between fourteen and thirty days following its appearance. One case presented excoriation about the size of a lentil. The erythema changed into pigmentation of the skin in brunettes and cachectic individuals. No delayed reaction was observed. Albers-Schönberg continued experiments on absorption and found that a cotton pillow was sufficient to filter out all of the soft roentgen rays. He also found that the skin of the chest was more sensitive to the rays from the Lindemann

* From the Department of Dermatology and Syphilology, New York Post Graduate Medical School and Hospital. Read by invitation before the New York Roentgen Ray Society, October 17, 1927.

tube than the skin of other parts of the body.

Quoting Albers-Schönberg, Brauer[4] in 1911 wrote an article on his experience with rays produced with Lindemann tubes. Brauer found that the extremities required larger doses for reactions than other parts of the body. The latter two observers agreed that the early reaction with the Lindemann tube rays depended upon the magnitude of the applied dose. When equal doses were given, the degree of the early reaction varied very slightly with different individuals. Albers-Schönberg concluded that the Lindemann glass window permitted the extremely soft roentgen rays to pass through. Later Schultz reported cutaneous reactions following large doses of "oversoft" roentgen rays. A redness and swelling of the skin followed by blistering and ulceration appeared. The pain reported was mild, the latent period very short. Healing occurred rapidly and sequelae occurred infrequently. Schultz also employed ordinary glass roentgen-ray tubes which were constructed with extremely thin glass walls opposite the anodes. These latter tubes were called skin tubes ("Berger central treatment tubes and Grisson's treatment tubes") and were manufactured by various firms at that time.

Stern[5] in this country who experimented with very long wave length roentgen therapy about 1910 reported unfavorable sequelae. Zehden[6] reported results from the use of oversoft roentgen rays which coincided somewhat with those obtained by Schultz. A glass composition of silicoborate of soda and alumina was produced by Schott[7] as far back as 1898. This glass had a low atomic weight and was capable of transmitting roentgen rays of extremely long wave lengths. Later Phillips[8] made a glass composition of silicate of soda and borax with a little lead that permitted passage of supersoft roentgen rays. The Lindemann glass followed a short time later and this glass was made of lithium borate. This lithium borate glass which is now known as Lindemann glass, is easily destructible. Schultz and Krause both used Lindemann tubes according to Gabriel.[9]

Bucky[10] since 1925 has written several articles on rays produced by tubes having Lindemann glass windows. The rays produced by this tube averaged 2 Å in wave length. He used Müller tubes. The Müller tube has an anode which is built into the walls of the tube in the shape of a cone. The window of this tube is of Lindemann glass.

In May, 1927, at the annual meeting of the Dermatological Section of the American Medical Association, Bucky and the writer[11] reported their results after sixteen months' work with rays averaging 2 Å in wave length. They used Müller tubes which were activated by 5–10 kv. The average voltage used was 9 kv. Twenty-seven different skin diseases were treated, some of which responded quite favorably to treatment with this ray. They also reported biological and physical properties of these rays. Bucky[12] independently had reported "that up to the present the following skin diseases were successfully treated;—eczemas of different kinds, acne rosacea, lichen planus and pruritus ani. Psoriasis reacted also but recurred after a strikingly short time. Of the infectious diseases, the following reacted well:—lupus, trichophytosis, sycosis, herpes tonsurans, kerion celsi, paronychia, angulus infectiosus and carbuncle; of the tumors: warts, mycosis fungoides, Kaposi's disease and epithelioma. Comparatively thick tumors also react very well, even if there seems to be a disproportion in the layer thickness and the penetration of the rays." In his summary, Bucky concluded that "the Grenz rays would replace the roentgen rays in dermatology to a great extent." He also concluded that "these rays are entirely harmless, because with the proper technique they are absorbed by the upper layers of the skin saving the germinative layers." Since this article appeared many observers have reported their results obtained with rays of 2 Å, but none of them has drawn the optimistic conclusions that Bucky has. Among them are Gabriel,[13] Martenstein and Granzow-Irrgang[14] Kirsch,[15] MacKee[16] and others. Other articles which have appeared have been by Mannheimer[17] and Martenstein and Juon.[18]

MacKee says that former workers in the field of soft roentgen rays were limited to

the use of induction coils, gas tubes and less accurate instruments of measurement than are obtainable today. Modern workers have had the advantage of the use of a hot cathode tube, an interrupterless transformer, spectrograph, iontoquantimeter, voltmeter and other modern apparatus and instruments in addition to knowledge that has been handed down by early investigators in the same field. Most of the previous workers probably used between 15 and 20 kv., while the present workers have been using 10 kv. or less.

be used by the addition of a step-down transformer constructed in such a way as to produce 10 kv. and 10 ma.

PHYSICS

Bucky with Glasser[19] making estimations with a spectrograph and an iontoquantimeter of wave lengths obtained from a Müller tube activated with voltages up to 10 kv. reported the rays as ranging between 1.6 Å to 2.06 Å. The radiation was heterogeneous.[16] Bucky states that the radiation produced with 9 or 10 kv. has a

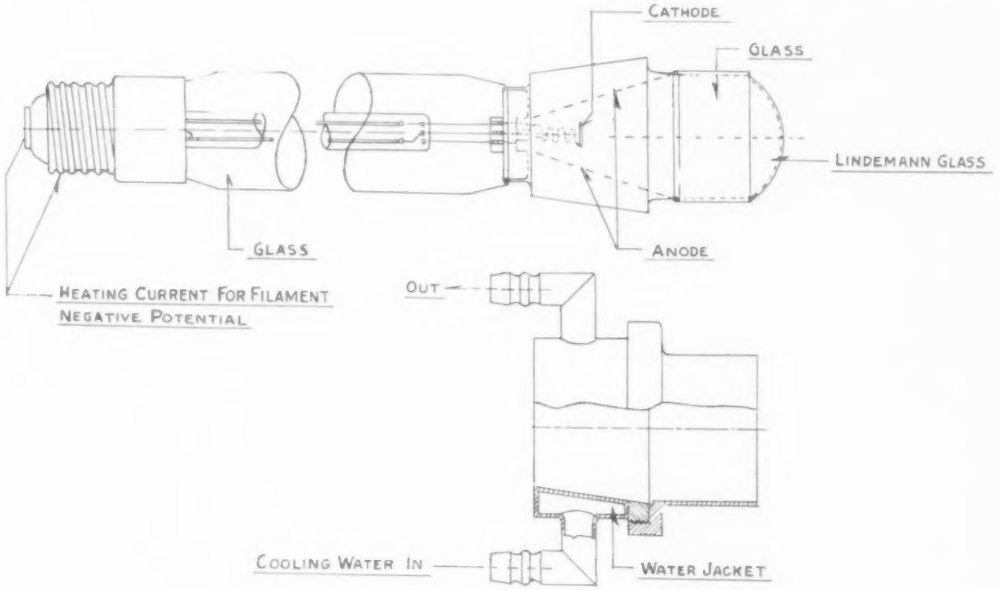


FIG. 1.

The tube which is manufactured by Müller of Berlin, is of the hot cathode type. Its conical hollow anode forms part of the tube wall. The tube is closed with a Lindemann glass window. The tube walls are enclosed in a protective metal housing. It is unipolar, and is water cooled. The tube water jacket is connected to a cooling unit which consists of a tank of water and an electric pump.

Apparatus. A special transformer designed to supply a maximum of 12 kv. and 10 ma. is used for the Müller tube. The principle of such a transformer does not differ from that of the modern interrupterless transformer as the latter could

half absorption value of about 0.5 mm. of aluminum and 0.7 mm. of water and that the half absorption value for water is about that for human skin. Bucky maintains that these rays are borderline rays ranging in the spectrum between the ultraviolet rays and roentgen rays. He uses the term "grenz" ray, which most observers feel is a misleading term. Gabriel,[13] investigating these rays, stated that he had carried out a series of physical tests with the Müller tube in an effort to define the quality of radiation produced. Through animal experiments and capillary microscope studies on the human skin he came to the conclusion that there is no practical

difference in the action of these long wave length rays and the wave length roentgen rays in common use. He therefore states that "there is no reason why these rays should be set aside as a special radiation differing from X-rays."

of the incidental radiation reaches the hair follicles. They found that with an erythema dose the basal cell layers and papillary bodies of the skin receive a considerable quantity of these rays. Below the papillae and the sub-papillary layer there are still

FIG. 2.

Martenstein [13] and Granzow-Irrgang [14] conducted supersoft roentgen-ray experiments with the Müller tube and apparatus in order to determine the penetration quality of the rays used by Bucky. They disagreed with Bucky that only 1 per cent

intensities at a depth of 0.4 mm. of $\frac{1}{3}$ of an erythema dose, and these quantities of roentgen rays can, if repeated several times, produce roentgen-ray sequelae. "It is therefore to be concluded that doses reaching the subcutis are considerably

larger than those given by Bucky and that with repeated dosages it is impossible to claim that this radiation is free of danger." Martenstein and Juon[18] stated their conclusions:

"1. That we as well as Gabriel, cannot find a justification for the separation of the grenz rays from the roentgen rays with respect to their biological action; 2. That the soft ray therapy advocated by Bucky is not an 'actual surface therapy' but that considerable quantities of rays reach down to the cutis and into the upper tissue end of it. There is, therefore, no such thing as a therapy free from danger, such as he claims, but we can, with certainty, expect late injury to the skin and we therefore advise caution in the use of this therapy in practice."

Gabriel and Martenstein both disagreed with Bucky that these very long wave length roentgen rays would practically replace the usual roentgen rays used in therapy.

Bucky published absorption data of celluloid and found using a Siemen's dosimeter, the following half-value layers:

Celluloid	
5 kv.	ca. 0.35 mm.
6 kv.	0.4 mm.
8 kv.	0.55 mm.
10 kv.	0.8 mm.

Later on Bucky gave data measured by Glasser as follows:

Water	
6 kv	0.26 mm.
8 kv	0.46 mm.
10 kv	0.74 mm.
12 kv	0.91 mm.

stating that the absorption in water is about the same as that in the skin, and assumes that the skin has a regular thickness of 1.5 mm. and does not consider that there are very considerable variations from that.

Martenstein again disagrees with the later statements made by Bucky. Martenstein states that comparative measurements show that the iontoquantimeter, because of the considerable wall thickness, cannot be used, and that the Sabouraud-Noiré tablets are not sensitive enough. He says that Kienböck strips have proven more satisfactory. Martenstein measured the absorption value in the skin of rabbits, guinea pigs and mice, and later in human skin, and claims that observations made with animal skin cannot be compared to those made in human skin.

Bucky's published penetration data of the so-called "grenz" rays shows it to be very small. Two millimeters of water will absorb more than 90 per cent of these rays; "therefore 2 mm. of tissue absorbed almost the same amount."

Robertson[20] gives the range of ultraviolet rays as being between 4000 and 200 Å and roentgen rays from 500 to 0.06 Å.

The following table is given by Bachem.[21]

Radiation	*Wave Length*	
Electric waves	10 kilometers to 1 millimeter	wireless telegraphy, diathermy
Infra-red or heat waves	0.3 millimeters to 0.00077 millimeters=7700 AU	longest mercury vapor radiation
Visible light	7700 AU to 4000 AU	red
		violet
	4000 AU	near ultraviolet limit of sun's spectrum
	3000 AU	
Ultraviolet rays	1800 AU	far ultraviolet, bactericidal
	200 AU	shortest observed ultraviolet radiation (Millikan)
	725 AU	longest known Roentgen Radiation (1923, December)
X-rays	about 5 AU	radiation used for diagnostic purposes
	about 0.3 AU	
	about 0.3	radiation used in deep therapy
	about 0.06 AU	
	0.058 AU	Hardest X-rays, Dessauer and Back (1919)
	0.1 AU	soft γ-rays
		hard γ-rays
Radium rays	about 0.025 AU	estimated from observations by Rutherford, Andrade, Compton
	0.01 AU	limit not definitely known

This table shows that the shortest ultraviolet rays and the longest roentgen rays overlap. Therefore the wave lengths used by Bucky (2 Å) fall well within the roentgen-ray spectrum. Within a certain range the same radiation can therefore be produced in optics or by means of the roentgen-ray tubes. Bachem gives the roentgen-ray range between 725 A and 0.05 Å. These data disagree with Bucky that the 2 A waves which he used is a ray different from that of the usual roentgen ray. Pusey[22] also stated that "Bucky's so-called 'grenz' rays are nothing but X-rays of long wave lengths."

The writer demonstrated that wave lengths of about 2 Å have considerable penetrating effect. A roentgenogram of the little finger was obtained with the following factors: Müller tube, 8 kv., 8 ma., distance, 5 cm.; time, 4 minutes. At a distance of 6 cm., and an exposure of 30 seconds, other factors unchanged, a roent-

genogram of a metallic object was obtained through 0.25 mm. aluminum. With an exposure of 4 minutes, a photographic shadow was obtained through 1 mm. aluminum. A definite fluorescence was produced on a Patterson fluoroscopic screen at a distance of 5 cm., with a filter of 0.25 mm. aluminum. With a still lower voltage, because of lessened penetration, it was possible to demonstrate photographic shadows of cellulose fibers of tissue paper and silk threads.

The following table shows the results of photographs taken with dental roentgen-ray films, using the Müller tube.

Exposure No.	Time in Min.	Filter	Kv.	Ma.	Results	Dist. Cm.
0	1/2	0.25 mm. Al	8	8	clear picture	6
1	1	0.25 mm. Al	8	8	clear picture	6
2	1 1/2	0.25 mm. Al	8	8	clear picture	6
3	2	0.25 mm. Al	8	8	clear picture	6
4	2 1/2	0.25 mm. Al	8	8	clear picture	6
5	3	0.25 mm. Al	8	8	clear picture	6
6	4	1 mm. Al	8	8	distinct but not as sharp as others	6

One may see from the above table that after one-half minute of exposure, the 0.25 mm. of aluminum offers practically no resistance to these rays. In exposure No. 6, in which 1 mm. aluminum filter was used, enough radiation was transmitted to show the lead number.

Shortest Wave-Length Angstrom Units	Voltage Peak Kilo Volts
1.24	10
0.62	20
0.414	30
0.310	40
0.248	50
0.207	60
0.177	70
.155	80
.138	90
.124	100
.113	110
.103	120
.095	130
.089	140
.083	150
.078	160
.073	170
.069	180
.065	190
.062	200
.059	210
.056	220
.054	230
.052	240
.050	250

There is absolutely no question that these are regular roentgen rays in every respect. There is no other radiation known which would produce these results.

Hirsch[23] gives the preceding table showing the relationship between the voltage peak in kilovolts and the shortest wave lengths in Angström units.

Further photographic experiments to determine the penetrability of waves averaging 2 A in wave length were conducted by Dr. Charles Lerner of New York. The following table shows his findings.

Distance in Cm.	Filter in Mm. Al	Time in Sec.	Kv.	Ma.	Result
6	0.25	5	8	8	clear image
6	0.25	10	8	8	clear image
6	0.25	15	8	8	clear image
6	0.25	20	8	8	clear image
6	0.25	25	8	8	clear image
6	0.5	5	8	8	negative
6	0.5	10	8	8	negative
6	0.5	15	8	8	negative
6	0.5	20	8	8	negative
6	0.5	25	8	8	negative
6	0.75	5	8	8	negative
6	0.75	10	8	8	negative
6	0.75	15	8	8	negative
6	0.75	20	8	8	negative
6	0.75	25	8	8	negative
6	1	5	8	8	negative
6	1	10	8	8	negative
6	1	15	8	8	negative
6	1	20	8	8	negative
6	1	25	8	8	negative
15	0	20	8	8	clear image
15	0.25	30	8	8	clear image

As can be seen from the above chart, lead numbers were exposed through various thicknesses of aluminum for 5, 10, 15, 20, 25 and 30 seconds at distances of 6 and 15 cm. With a time exposure as short as 5 seconds sufficient rays penetrated 0.25 mm. of aluminum to produce a clear image. A very clear image was also produced at a distance of 15 cm. An exposure of 25 seconds, however, was insufficient to produce an image through thicknesses of more than 0.25 mm. of aluminum.

BIOLOGY

In 1925–26 Bucky reported unusual biological actions for rays having wave lengths of about 2 Angström units. He claimed that normal epidermis absorbed most of these rays and that there was no direct action on the subcutis. He asserted that it was impossible for sequelae to develop even with marked erythema doses when using 10 kv. or less. Bucky produced a temporary leucocyte drop in about fifteen minutes, and a return to normal in about one hour by giving small doses to small areas of skin. He said that this did not occur with ultraviolet radiation or with roentgen rays of any wave length. Gabriel[13] published curves demonstrating the drop of the leucocytes following exposure to "grenz rays" in man and rabbits. Gabriel found, however, that the same drop took place after an irradiation with roentgen rays of short wave lengths with the only difference that the minimum is reached a little later, followed by a slower return to normal. Other investigators have also been able to increase and decrease the leucocyte count with roentgen rays of any wave length.

Supersoft roentgen rays are similar to the ordinary roentgen rays in that they produce an erythema, have penetration, may also have a latent erythema, produce pigmentation, and have accumulation from successive treatments. They differ from the biological effects of the usual roentgen rays in that after large doses with the supersoft rays the erythema may appear almost instantaneously, whereas with roentgen rays, even in large doses, it may take from three days to three weeks to appear. The penetration of the supersoft rays being very much less than that of the roentgen rays, an erythema or a double erythema dose can be given without a temporary or permanent epilation of hair; while with the usual roentgen rays there is first an epilation of hair, and as the dose increases an erythema appears. The sequelae following large doses of roentgen rays are telangiectasia, pigmentation, atrophy, and, later, epithelioma; while with supersoft rays of 8 kv., no atrophy or telangiectasia has been noticed after two years' observation of cases having received marked erythema doses. However, it is quite possible that sequelae may yet appear, and if so will be reported later by the writer. Supersoft roentgen rays simulate the ultraviolet rays in some respects. They both produce an erythema and pigmentation. They differ from each other in that the ultraviolet rays have much less penetration and do not have a delayed erythema over six hours. The writer has observed late erythemas with supersoft roentgen rays in two and one-half to four weeks following mild erythema doses. Schultz, using extremely soft roentgen rays, reported reactions which were painless and the areas did not present atrophy for fifteen months subsequent to the treatments. He, however, warned of the danger of these rays and stated that the cases might later develop roentgen-ray sequelae. His early death caused a discontinuance of his work. Martenstein and Granzow-Irrgang made experiments with the human skin, using the Müller tube. They came to the conclusion that in giving a mild erythema dose a considerable quantity of rays reached the lower layers which within a few days showed distinct changes in the tissue structure. An experiment performed by them using the skin of a mouse, which is approximately twice as thick as the human epidermis, showed that an erythema dose produced almost as much reaction as in normal human skin. With 13 kv. and 15 ma., Buschke and Sklarz[24] found ulceration, epilation, widening of blood vessels, and edema of the exposed skin. With 12 kv., 15 ma., and 15 cm. distance, 7.5 min., there was a destruction of the skin with scarring. With lower voltages there were no permanent changes. Gabriel exposed human skin with supersoft roentgen rays and found a distinct increase of the capillary vessels and widening of their diameters. He felt therefore that even with 9 to 10 kv. there was a definite quantity of these rays penetrating through the skin down to the lower layers of the subcutis.

Fuhs[25] of Vienna, recently reported his investigation of very soft roentgen rays, employing a Müller soft ray tube and using the dosages advocated by Bucky. He found that there was no epilation below

9 kv. and stated that "Bucky's claim that 95 per cent of skin diseases are better treated with grenz rays than with roentgen rays is not justified." Fuhs reported good results with this ray in the treatment of tuberculosis verrucosa cutis, erythema induratum, mycosis fungoides, lichen chronicus Vidal, and basal cell epitheliomas. His results were poor in lupus vulgaris, papulonecrotic tuberculide, acne vulgaris, rosacea, pruritus ani and pruritus vulvae, verruca plana and vulgaris, clavus, keloid, nevus flammeus, and psoriasis. Fuhs was of the opinion that "these rays have a great safety factor."

For practical purposes the writer adopted a standard dosage as a means of measurement. One unit was considered the dose which was necessary to produce a mild erythema within twenty-four hours after exposure on the flexor surface of the extremity of a young brunette adult. That is to say, this dose would produce the above effect in most cases but there have been instances in which with this so-called one unit there was a delayed erythema of two to four weeks. The following factors were used in determining the standard unit: Müller tube, 8 kv., 8 ma., distance 6 cm., time 3 minutes. This could be called a first degree erythema and as one increases the time the degree of erythema increases. A unit dose causes a redness which usually appears within the first twenty-four hours, may appear within the first few hours, and in exceptional instances may be delayed one month. Following the one unit erythema there is usually a slight desquamation and pigmentation. It was found that this dose could be repeated with comparative safety at intervals of two to four weeks for a few doses. Most diseases required one to two unit doses for results. The latter dose usually caused an erythema to appear within the first six hours after exposure, which erythema was followed shortly by an edema, pinhead sized vesicles, and desquamation. The reactions often persisted for several weeks following the treatment. The treated areas healed with no apparent roentgen-ray sequelae. Of course it is not known whether or not they might appear later. As yet no epilation has been observed from repeated doses of two units. Larger vesicles and even bullae may appear following three or four unit doses, but even with three unit exposures atrophy or telangiectasis has not been observed for one year. This applies to exposures where the unit was measured with the above factors. One case[11] in which 15,000 volts were used resulted in atrophy and telangiectasia. It is generally known that atrophy and telangiectasia may not appear at times for several years following irradiation with roentgen rays and although using 10 kv. has not to date given these sequelae they may appear in the future, and the writer warns workers utilizing these rays to be most cautious. The largest area which can be exposed at one time conveniently with the supersoft roentgen rays (Müller tube) is about 3 inches in diameter and for this the tube is placed about 10 cm. from the target to the skin; for the treatment of a silver-dollar sized area the tube is placed about 6 cm. from the target to the skin. The patients usually complain of pain, tenderness and itching of the exposed areas subsequent to one unit or larger doses. Skin previously irradiated with the ordinary roentgen rays reacts markedly to fractional doses of the supersoft roentgen rays. The writer has seen ¼ unit doses of supersoft roentgen rays cause very marked erythemas in skin which had received but a few small doses of ordinary roentgen rays.

THERAPY

For the past two years the writer has used supersoft roentgen rays (2 A) in the treatment of about thirty different skin diseases. Therapeutically the results have been found to be satisfactory in dermatophytosis, Duhring's disease, basal cell epitheliomas particularly of the eyelids, lichen planus hypertrophicus, perlèche, tinea capitis, verruca vulgaris, small keloids when treated early, neurodermatitis, and sycosis barbae. The results were less satisfactory in cases of acne vulgaris, acne keloid, angioma cavernosum, herpes zoster, lupus erythematosus, leucoplakia, parapsoriasis, psoriasis and lupus vulgaris. The following diseases received no improvement from this ray: xanthelasma, urti-

caria pigmentosa, and leucoplakia of the tongue. In lupus erythematosus the lesions disappeared rapidly, only to return in a few days. One case each of paronychia, rosacea, and sarcoid was cured. One case of multiple flat epitheliomas of the skin was cured. In the opinion of the author the most striking results obtained with this ray were in the treatment of epithelioma (basal cell type) of the eyelids. Without protecting the eyeball doses of 2 units were given to lids affected with definite epitheliomas. Several cases have been cured with this therapy. The eyeballs were examined frequently during the course of treatment and no irritation of the eyeball was observed by the ophthalmologists at any time. The epitheliomas disappeared permanently leaving the skin apparently normal. The one striking instance in which the soft ray is superior to the roentgen rays of shorter wave lengths is in the treatment of epitheliomas of the eyelids. Another great advantage of the supersoft roentgen ray is its greater factor of safety. While one cannot be sure that roentgen-ray sequelae will not appear following the use of supersoft roentgen rays with 8 kv. or less, it can be assumed that sequelae are very much less likely to appear than with the usual roentgen rays.

NOMENCLATURE

Schultz called the very soft roentgen rays which he used "oversoft rays." Bucky[12] used the term "grenz" because "the name intends to emphasize the differences of the biologic actions. In fact the 'grenz' rays create biologic effects which stand in the middle between those of ultraviolet and roentgen rays." The word "grenz" is misleading as it means borderline and implies a new radiation. "Infraroentgen" is not satisfactory because the rays are really in the roentgen-ray spectrum and not below it as this term might imply.. "Extremely long wave length roentgen rays" would be a correct though awkward name. Although the term "supersoft roentgen rays" is not a scientific one, the writer prefers it for it is somewhat explanatory of the type of ray used and is not misleading.

CONCLUSIONS

1. Electromagnetic vibrations of 2 Ångström units in wave length are very soft roentgen rays.

2. These rays have all the physical properties of roentgen rays.

3. With a voltage of 8 kv. or less no sequelae have been observed after two years. Therefore the rays can be employed with a greater degree of safety than ordinary roentgen rays.

4. Many skin diseases have responded quite favorably to treatment with these rays, particularly epitheliomas of the eyelids.

5. In the writer's opinion, these rays will ultimately find an important though limited place in the armamentarium of the dermatologist.

6. The writer does not feel that supersoft roentgen rays (2 Å) will replace the usual roentgen rays in the treatment of skin diseases.

REFERENCES

1. Schultz, F. X-ray Treatment of Skin Diseases Rebman Company. Pp. 61, 81, 82 and 92.
2. Albers-Schönberg. Die Lindemannröhre. Frühreaktion. Expositions-abkürzung. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1911, xvii, 225–229.
3. Albers-Schönberg. 4th ed., p. 141.
4. Brauer, A. Das Röntgenprimärerythem (Frühreaktion). *Deutsche med. Wchnschr.*, 1911, xxxvii, 538–541.
5. Stern. Discussion before the Section on Dermatology and Syphilology of the New York Academy of Medicine, February, 1926.
6. Zehden. Quoted by Gabriel, ref. 13.
7. Schott. Quoted by Kaye, G. W. C. X-rays. Longmans, Green & Co., 2d ed., 1917, p. 171.
8. Phillips. Quoted by Kaye, G. W. C. X-rays. Longmans, Green & Co., 2d ed., 1917, p. 171.
9. Gabriel. Weitere Untersuchungen über die sogenannte Grenzstrahlung. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1927, xxxvi (Kongressheft), 72–73; 74.
10. Bucky, G. Reine Oberflächentherapie mit überweichen Röntgenstrahlen. *München. med. Wchnschr.*, 1925, lxxii, 802–806. *Jabresk. f. ärztl. Fortbild.*, August, 1926. Tatsächliche Oberflächentherapie und ihre Beziehungen zu inneren Organen. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1926, xxxiv (Kongressheft), 41. Grundlinien und Ausblicke der Grenzstrahlentherapie. *Strahlentherapie*, 1927, xxiv, 524–533.
    Bucky, G., and Müller, E. F. Strahlende Energie, Haut und autonomes Nervensystem. *München. med. Wchnschr.*, 1925, lxxii, 883–885.
    Bucky, G., and Manheimer, Olga. Ueber Grenzstrahlung. iv. Strahlende Energie, Haut und Blutdruck. *Strahlentherapie*, 1926, xxiii, 264–271.
11. Eller, J. J., and Bucky, G. The Grenz (infraroentgen) rays in dermatology; preliminary report of the clinical and biological observations.

Read before American Medical Association, May, 1927. To be published in *Arch. Dermat. & Syphilol.*

12. Bucky, G. Actual superficial therapy by "Grenz" (infra-roentgen) rays. *Arch. Dermat. & Syphilol.*, 1927, xv, 672–677.
13. Gabriel, G. Physikalische und biologische Untersuchungen über die sogenannte Grenzstrahlen. *Strahlentherapie*, 1927, xxiv, 534–547. Weitere Untersuchungen über die sog. Grenzstrahlung. *Strahlentherapie*, 1927, xxvi, 189–199.
14. Martenstein, H., and Granzow-Irrgang, D. Ist die "Grenzstrahlentherapie" nach Bucky vollkommen ungefährlich? I. Physikalische Untersuchungen. *Strahlentherapie*, 1927, xxvi, 162–176.
15. Kirsch, Hans. Physikalische Untersuchungen über die Buckyschen Grenzstrahlen. *München. med. Wchnschr.*, April 8, 1927, lxxiv, 578–579.
16. MacKee, G. M. X-rays and Radium in the Treatment of Diseases of the Skin. 2d ed. Appendix pp. 749–759; pp. 425–427. Lea & Febiger, Philadelphia, 1927.
17. Manheimer, O. Discussion of paper by Gabriel. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1927, xxxvi (Kongressheft), 73–74.
18. Martenstein, H., and Juon, M. Ist die "Grenzstrahlentherapie" nach Bucky vollkommen ungefährlich? II. Biologische Untersuchungen. *Strahlentherapie*, 1927, xxvi, 177–188.
19. Glasser, O. Collaborator of Bucky.
20. Robertson, John K. X-rays and X-ray Apparatus. Macmillan Co., New York, 1924, p. 143.
21. Bachem, Albert. Principles of X-ray and Radium Dosage. Albert Bachem, Chicago, 1923, p. 95.
22. Pusey. Discussion of paper read at meeting of American Medical Association, May, 1927.
23. Hirsch, I. Seth. The Principles and Practice of Roentgen Therapy, with Dosage Formulae and Dosage Table by Guido Holzknecht. American X-ray Publishing Co., New York, 1925, p. 124.
24. Buschke and Sklarz. Quoted by Gabriel.
25. Fuhs, Herbert. Über die Behandlung von Hautkrankheiten mit Buckys Grenzstrahlen. *Strahlentherapie*, 1927, xxvi, 657–674.

RICKETS OCCURRING LATE IN CHRONIC INTERSTITIAL NEPHRITIS

REPORT OF A CASE

BY ROLLA G. KARSHNER, M.D.

LOS ANGELES, CALIFORNIA

INTRODUCTION

SO-CALLED renal dwarfism (renal rickets, renal infantilism, rickets of adolescents) is unmentioned in most textbooks of pediatrics and orthopedics, and no cognizance has been taken of the condition in roentgenological literature.

Rickets is a disease of man and domesticated animals. It is limited practically to the temperate zone where its incidence is seasonal, being greatest in the winter when the active rays of the sun are at a minimum. It seems to have been unknown prior to the time of its description by Glisson in 1650, when man began to live indoors and feed his infants artificially. If it existed in ancient times, it did so rarely, because the deformities of the disease were not described by the Hippocratic or Galenic schools. They are not demonstrable in ancient human bones; neither are they reproduced in the sculpture or painting of antiquity which have portrayed with fidelity the results of other dystrophies. During the fifteenth century, however, when feudalism was giving way to industrialism and the crowding of population into walled cities and when all Europe was suffering from the ravages of wars, plagues and famine, certain religious paintings showed evidence of clinical rickets in infants. Rachitic changes have been found in the bones of monkeys that were confined in the temple of Thebes more than two thousand years ago.

The word rickets has been used in medical writings to describe numerous conditions which soften or deform bone or retard osseous development. Thus one comes across "fetal rickets" applied to achondroplasia and osteopsathyrosis, "hemorrhagic rickets" applied to infantile scurvy. Today rickets is regarded as a constitutional disease occurring in infancy which, in addition to definite clinical signs and symptoms exhibits a disturbed calcium-phosphorus ratio in the blood, and consequent changes in the bones readily recognized on the roentgenogram, and assumed to be produced by (1) deprivation of active light rays; (2) deprivation of an unidentified factor con-

tained in cod liver oil; (3) deprivation of calcium or phosphorus in the diet, or inability to absorb or utilize such elements when supplied in the diet.

Late rickets occurring in childhood and adolescence is regarded as differing from commonly accepted rickets only in age of incidence.

Experimentally rickets can be produced in rats by a ration low either in phosphorus or calcium. Cod liver oil as well as radiant energy will protect animals so fed. Various foods, cotton seed oil and linseed oil may be activated by irradiation with ultraviolet light. Irradiated milk cures rickets in infants as demonstrated by the roentgen ray, the retention in the blood of calcium and phosphorus being identical with that following cod liver oil, ultraviolet rays or sunlight. Irradiated cholesterol protects when given subcutaneously.

Hess and associates have postulated that the cholesterol in the skin is activated by irradiation, and were able to protect animals fed a rickets-producing diet by adding to the diet irradiated skin. They have also shown that a chemical change takes place in irradiated activated cholesterol. However, the antirachitic properties may reside in some contaminating substance. Present opinion holds that the protective and curative action of cod liver oil, active light rays and irradiated cholesterol and other substances is dependent upon the presence or production of the antirachitic vitamine D. The mechanism of the beneficial action is not known.

Possibly at times other factors are at work. The diet of the infant fed on cow's milk contains more than adequate amounts of calcium and phosphorus. However, in rickets little is absorbed, the larger part of the phosphorus and almost all of the calcium being found in the stools. When high calcium intake is supplied there is a depression of phosphorus absorption, and vice versa. It has been found that during a period of hydrochloric acid ingestion more phosphorus and calcium appears in the urine and less in the feces than during a similar period of daily doses of sodium bicarbonate. Thus hypoacidity occurring in infantile diseases conceivably could predispose to rickets.

Rickets embraces more than one kind of disturbance of mineral metabolism. We identify low calcium rickets in which the calcium content of the blood serum is reduced and in which tetany may occur, and the more frequent low phosphorus rickets in which the content of inorganic phosphorus in the blood serum is reduced. These have similar macroscopic appearances and microscopic changes that differ in degree rather than kind.

The mineral matter of all bone is composed chiefly of tricalcium phosphate. This salt is only slightly water soluble, but more so in the presence of carbonic acid, as in the blood serum. Howland and his coworkers have shown that the precipitation of this salt *in vitro* and *in vivo* follows the law of mass action; that there is apparently a solubility product constant for Ca and HPO_4 ions in the blood serum having a definite value at a given pH and temperature. When the constant is exceeded precipitation and consequently calcification in the epiphyseal cartilage take place. When the concentration of either ion is very low there will be no precipitation because the other ion cannot increase in the serum indefinitely. The normal for calcium in an infant is around 10 or 11 mg. per 100 c.c. of serum; for phosphorus it averages 6 in the breast fed and about 5.5 in the healthy artificially fed. They found that when the concentration of the calcium is multiplied by the inorganic phosphorus concentration, each expressed in milligrams per 100 c.c. of serum, the product in the normal child is between 50 and 60. When the product is below 30 rickets is invariably present; when above 40, either demonstrable healing is taking place, or there has been no rickets. Products between 30 and 40 denote rickets.

In 1883 Lucas remarked that the "phenomena of late rickets and albuminuria are too frequently connected to be matters of chance." This observation passed unnoticed for practically thirty years, when the coincidence again attracted attention. During the past fifteen years British medical literature has contained accounts of perhaps 50 cases of an entity which Barber has called renal dwarfism and defines as

"a condition of stunted development, associated with bone deformities of the late rickets type, due to an insidious chronic interstitial nephritis, of obscure etiology." It constitutes a hitherto not generally recognized disease of the malacic group. In character it is hypoplastic. In its roentgen appearance it is indistinguishable from rickets; clinically it will present itself as a variety of late rickets, though etiologically it is obviously different. Four recent American cases have been reported.

Rickets may eventually be proven to have as varied an etiology as tetany. The following example is one of a class in which a disturbed calcium-phosphorus metabolism may result from impaired excretory function.

Fig. 1. Pelvis and upper femora showing reduced bone density, coarse bony texture, typical rachitic changes of epiphyseal lines, and deformity of the long bones.

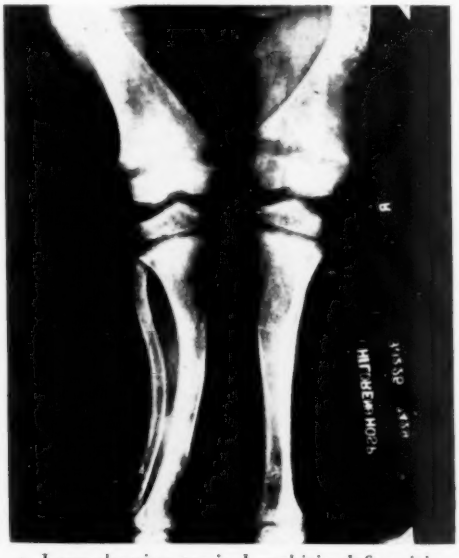


Fig. 2. Legs showing typical rachitic deformities, epiphyseal lines and the irregular reduced bone density and coarse bony texture.

CASE REPORT

A girl, aged seven and a half years was brought to the Outpatient Department of the Children's Hospital, March 5, 1925, because she was not getting on and her legs were recently becoming deformed.

Her father was sixty-five years of age and his blood Wassermann was 4 plus. There was no further evidence of lues or other significant disease in the family.

The child was born in California, full term, normal delivery, birth weight 8¼ pounds, breast fed eleven months, then goat's milk. She walked at three and a half years. Attempting to walk at two years and nine months she sustained a fracture of the left femur. The first teeth appeared at normal age but rapidly decayed. Inquiry revealed that her diet had been proper and she had enjoyed much exposure to sunlight. For years she had been variously treated for rickets. There was an indefinite history of an attack suggesting tetany. For years there was polydipsia and polyuria.

Height 37 inches, weight 33 pounds. The skin was dry. The facies somewhat resembled those of a cretin. There were prominent bosses, the nose was flat and rather broad. The teeth were carious. The ribs were beaded, the epiphyses enlarged. There was a Harrison's groove and pot belly. The legs were bowed with genu valgum. The posture was atonic, the knees and hips flexed, shoulders drooping, head forward, abdominal wall grooved, and a lumbar lordosis.

Single specimen of the urine showed sp. gr. 1.010, much albumin, slight reduction of copper solution, faint trace of acetone, hyaline and granular casts, occasional red blood cell.

Roentgen examination of all the bones showed the entire skull probably of reduced bone density, the calvarium large with an area of reduced density in the left posterior parietal region less than a centimeter in diameter with irregular, punched-out borders; no areas of thickening; sella normal. The frontal and sphenoid sinuses were not excavated. The upper jaw was not well developed, causing an appearance of prognathism of the lower jaw.

The bones of the spine and ribs were of practically normal density; clavicles and scapulae of

reduced density. The anterior ends of the ribs were broadened and showed cupping. Pelvis was small and of reduced density.

The most marked changes were in the long bones. Both femora were bowed outward and forward. The shafts, particularly towards the ends, were of coarse, almost cystic texture and definitely reduced density. Bones of the leg were similarly affected and bowed inward and forward, with evidence suggesting healed fractures. The bones of the upper extremities presented changes similar to those of the lower. There were the normal number of centers of ossification in the wrists. The phalanges presented a porous reduction of density. All the

FIG. 3. Lateral view of right thigh and leg showing characteristic rachitic deformities, changes in bone density, texture and epiphyseal lines.

epiphyses were of reduced density, the epiphyseal lines ragged, the metaphyses of all the shafts flaring. The appearance of the epiphyses and epiphyseal lines was characteristic of active rickets, without any evidence of healing. The roentgen diagnosis was active late rickets.

She was treated in the Outpatient Department with diet, cod liver oil, quartz lamp, and endocrine preparations until June 30, 1925, without any change whatsoever in her condition, either clinically or roentgenographically.

The blood serum phosphorus was then found to be 4 mg. per 100 c.c. and the blood serum calcium was 8 mg. per 100 c.c. This being a low concentration, the child was admitted to the hospital and intensive treatment for rickets was undertaken. After a week the mother removed her against advice. Analysis of stomach contents showed 20 per cent free HCl, 45 per cent total acid, single specimen of the urine showed sp. gr. 1.007, positive albumin, slight reduction of copper solution, faint trace of acetone, no casts, 1 to 2 red blood cells per high power field. The hemoglobin was 70 per cent, red blood cells 4,240,000.

She was observed in the Outpatient Department until November 14, 1925, without any gain in weight, height, or improvement of condition. Then she was taken to another clinic and was treated with lights and endocrine preparations, her condition remaining unimproved. Her teeth crumbled and she is said to have had tetany in July, 1926.

FIG. 4. Hands and wrists showing typical rachitic cupping of metaphyses of the long bones of the forearms and porous reduced density of phalanges.

On September 21, 1926, she was admitted to the hospital on account of generalized edema, dyspnea and cardiac decompensation, and remained a week, when the mother again removed her against advice. The clinical diagnosis was rickets, cardiorenal disease, carious teeth, hypertrophied tonsils, anemia. Roentgen examination of the bones showed no change. The heart shadow was huge. Blood pressure 140 80, hemoglobin 50 per cent, red blood cells 2,100,000. Six specimens of urine showed sp. gr. 1.008 to 1.010, albumin in all, no reduction of copper, no acetone, none to occasional granular casts, few to many pus cells, none to 1 red blood cell per high power field.

Death ensued October 3, 1926, autopsy revealing chronic interstitial nephritis, small contracted kidneys, general anasarca, cardiac dilatation, adherent aortic cusps, atheromata of aorta and endocardium, large fibrous spleen, fatty liver, severe active rickets of the bones. The organs of internal secretion were negative.

The foregoing is a quite typical clinical history of a so-called renal dwarf. It is regrettable that more extensive chemical studies were not carried out. The literature affords the following description of the disease.

Etiology. The primary cause is as obscure as that of chronic interstitial nephritis. The sexes are equally divided. The cases show no evidence of antecedent disease, such as the usual acute infections, and there is nothing to indicate that the interstitial nephritis is preceded by parenchymatous disease of the kidneys. The malady is not dietetic, syphilitic, hereditary or familial. One or two cases at post mortem have suggested a chronic ascending infection of the urinary tract. Blood chemical studies of the English cases are not reported. Shipley, Park et al suggest that the bone changes may be dependent upon inability of the kidney properly to excrete phosphate, thus making it a low calcium rickets. Lathrop's case would support such contention, the calcium of the blood being reduced to practically one-half the normal and the phosphorus doubled. At no stage was there the slightest clinical evidence of tetany. However, the free calcium was 3.8 mg. which is normal and above the level at which tetany occurs. He suggests that the severe acidosis caused ionization of a sufficiently large proportion of the calcium to prevent tetany. In Hunt's patient there was a slight reduction of blood calcium and a slightly elevated blood phosphorus. My own case and that of Smith and Walsh, however, while showing reduced blood serum calcium, failed to show phosphorus increase. In fact, in my case the phosphorus was also reduced. While Marriott and Howland, Fetter, Boyd and associates have produced evidence that late stages of renal insufficiency often show increased phosphorus content of the blood associated with a decrease in the calcium content, it appears that such phosphorus retention is not the sole explanation of the low calcium rickets which occurs in chronic interstitial nephritis.

Pathology. The kidneys are small, contracted, with narrow cortex. Cysts and signs of defective development may be present. The picture is that of a progressive interstitial nephritis. The entire cardiovascular system is often negative. The heart frequently shows slight left ventricular hypertrophy. Rarely arterial changes have been noted. The endocrine glands are normal, although Ashcroft claims evidence suggesting suprarenal deficiency and a probably inactive thyroid. Microscopically, the bones in my case were similar to those previously studied, the rachitic process being more pronounced than has been frequently reported. The proliferative cartilage is irregular and calcification defective. Deep in the metaphysis are islands of cartilage bordered by calcium deposits accounting for the honeycomb appearance seen in the roentgenograms. The trabeculæ are thin with moderate borders of osteoid tissue. The whole is embedded in a loose fibrous tissue. There is no evidence of healing, the impression being that of prolonged impairment and delay of calcification.

Symptoms and Physical Findings. The onset is insidious. Kidney lesions are probably present in infancy, but the disease is most frequently overlooked until the development of bone deformities which usually occurs about puberty, although rachitic changes and deformities have in rare instances been noted at birth.

The patients present an unhealthy earthy pallor but no marked anemia except near the termination of the disease. The skin is dry and inelastic. It may be pigmented. In well-marked cases, if the child stands at all, the posture is atonic, the gait is waddling, with lumbar lordosis.

Headaches may be complained of, generally not severe. Drowsiness and vomiting may be present. However, the usual nephritic symptoms and edema are rare. Acidosis is common. Convulsions and tetany have been described. There is frequently polydipsia and polyuria. Cardiovascular involvement as a rule is slight. Thickened arteries have rarely been demonstrated. The heart sounds are not abnormal. The blood pressure is rarely increased except in the terminal stage in a few cases. Optic discs have shown albuminuric retinitis with hemorrhages.

Stunted growth is striking, more noticeable after the sixth or seventh year,

though the child may be small from birth. The deficiency in stature varies roughly from 6 to 16 inches. Fletcher's case did not grow after the first year. The weight is proportional to the height. Sexual development may be normal, delayed or absent. The patients are intelligent. Deformities associated with renal disease in older children have been seen without dwarfism.

Bone deformities such as thickened epiphyses and rachitic rosary are generally present. The most common is genu valgum which develops late and rapidly anywhere from the seventh to the eighteenth year, although it may be only an exaggeration of previously existing deformity. It was present in 14 of Barber's 17 cases. In 13 of these it was the symptom which brought the patient under observation. Its greatest incidence is at about puberty. Fractures are frequently described, usually taking place through the metaphysis, and evidently due to rarefaction, and substitution of fibrous for osseous tissue. Union always follows. Renal dwarfs are described without rickety changes in the bones. Several such have first been seen when free from bone deformity and have later come under observation for genu valgum.

Laboratory Findings. The urine is pale, the specific gravity below 1.010. Albumin in varying amounts is almost constant. Glycosuria, probably of renal origin has been described. Hyaline and granular casts may be present. Globulin has been found. One case showed blood. There may be anemia. The nitrogen retention is characteristic of the most severe nephritis.

Roentgenology. The roentgen picture is that of a mild or grave active rickets of the long bones with deformities, atrophy, general porotic rarefaction of the metaphyses, delayed union of the epiphyses, softening at the epiphyseal lines, often with saucer-shaped expansion and irregular fuzzy metaphyseal borders. There is generally no evidence of healing. Fractures similar to those in ordinary rickets are not uncommon, with subsequent union. Two of Ashcroft's patients showed thickening of the cranial vault. He also states that frequently ossification of the bones of the wrist is irregular, resulting in apparent fusion. The case of Smith and Walsh showed apparent fusing of the vertebrae. The cystic porosis of the phalanges seems to be general and is mentioned as a guide to the severity of the disease. Excessive deposition of poorly calcified bone under the periosteum has been described. In many of the reports the altered appearance of the metaphyses with delayed closure of the epiphyseal lines is stressed as the outstanding feature.

Course and Termination. Barber describes three stages: first, as it occurs in young children manifested by underdevelopment and thirst: second, toward puberty manifested by bone deformities, giving the picture of the typical renal dwarf with late rickets signs. His third stage is later and is only exceptionally reached. In it the epiphyses actually join the shafts. A fatal termination is inevitable, most frequently from uremia which may develop at any time, usually with acidosis. Several cases have died following osteotomy, the nephritis not having been discovered until post mortem. Death occurs usually in the seventh to seventeenth years, the greatest incidence being the middle of the second decade. A few of the milder cases have lived longer.

Diagnosis. This may not be obvious before bone deformity takes place. It should be suspected from the urine. Differentiation from diabetes insipidus, bilateral cystic kidney and bilateral renal calculus should not be difficult. Cameron has reported an instance in which he believed the latter condition to have produced renal dwarfism. Roentgen examination of the bones may show some disturbance of calcification.

Diagnosis should be easier after bone deformities have developed, when except for nephritis the disease is identical clinically and roentgenographically with late rickets. Albuminuria, reduced kidney efficiency and failure to respond to antirachitic treatment should make the diagnosis. Barber believes that many, if not most, fatal cases of late rickets have been renal dwarfs.

Prognosis. In the well-marked case there is little prospect that the condition can be arrested, a steady progress being the rule with a fatal termination generally in the second decade. Extent of kidney dam-

age may be ascertained from kidney function studies. Some cases have survived for years with an exceedingly high blood urea content. Uremia soon terminates the picture when the blood urea reaches 200 to 300 mg. per cent.

Treatment. There is little scope for treatment. Thyroid and other glandular extracts have no effect. Surgical interference is ill advised and likely to precipitate an attack of uremia. The employment of support for the legs may be wise. Ordinary measures directed against rickets are of no avail.

SUMMARY AND CONCLUSIONS

1. An instance is described of a child suffering from chronic interstitial nephritis who exhibited clinically, pathologically and roentgenographically the characteristics of active rickets, with onset at infancy and persistence until her death at nine years, in spite of intensive antirachitic measures.

2. In an extensive literature such a condition is described under various names because of varying conceptions of its etiology and pathology. It constitutes a specific morbid entity of the malacic group of bone diseases. It is a rickets of renal origin.

3. In 5 cases in which blood phosphorus and calcium determinations have been carried out, it is a low calcium rickets.

4. All cases of stunting of growth or late rickets should be examined carefully for nephritis, especially if operative correction of genu valgum, or other deformity, is contemplated.

5. Conversely, chronic interstitial nephritis being a rarity in infancy and childhood, all such cases should be subjected to roentgen examination of the bones for indications of rickets.

REFERENCES

Anderson, Grace H. Calcium and phosphorus content of blood in normal and rachitic children. *Brit. J. Child. Dis.*, 1924, xxi, 33–48; 107–119.

Ashcroft, G. V. Renal rickets. *J. Bone & Joint Surg.*, 1926, viii, 279–291.

Barber, H. Chronic interstitial nephritis in children; a brother and sister affected. *Brit. M. J.*, 1913, ii, 1204.

Barber, H. A case of interstitial nephritis with infantilism. *Lancet*, 1918, i, 142.

Barber, H. Bone deformities of renal dwarfism. *Lancet*, 1920, i, 18.

Barber, H. Renal dwarfism. *Quart. J. Med.*, 1921, xiv, 205.

Barber, H. Renal dwarfism; course of disease. *Guy's Hosp. Rep.*, 1926, lxxvi, 307–313.

Barlow, W. H. A case of granular contracted kidney (cirrhosis of kidney) in a child five years and eleven months. *Lancet*, 1874, ii, 151–153; 190–193.

Boyd, G. L., Courtney, A. M., and MacLachlan, I. F. Metabolism of salts in nephritis; calcium and phosphorus. *Am. J. Dis. Child.*, 1926, xxxii, 29–39.

Chick, H., et al. Studies of rickets in Vienna. Report to Accessory Food Factors Committee, London, 1923.

Davies-Colley, J. N. C. Juvenile osteomalacia. *Brit. M. J.*, 1884, i, 667–668.

Dubin, H. E., and Funk, C. Studies on the chemistry of cod liver oil. II. A cod liver oil concentrate manifesting both antirachitic and antiophthalmic properties. *Proc. Soc. Exper. Biol. & Med.*, 1924, xxi, 458–460.

Evans, E. L. Acute rickets in late childhood and adolescence. *Brit. M. J.*, 1923, ii, 1212–1213.

Evans, G. Arterio-sclerosis in children. *Quart. J. Med.*, 1922–23, xvi, 33–44.

Fairbank, H. A. T. Deformities associated with chronic nephritis. *Proc Roy. Soc. Med.*, 1921, xiv (*Sect. Surg., Subsect. Orthop.*), 21 and 28.

Feiling, A., and Holyoak, W. L. Case of renal dwarfism with optic atrophy. *Proc. Roy. Soc. Med.*, 1922, xv (*Clin. Sect.*), 1.

Fetter, W. J. Gravimetric estimation of phosphates of the blood. *Arch. Int. Med.*, 1923, xxxi, 413–422.

Findlay, L. Actiology of rickets. *Lancet*, 1922, i, 825–831.

Findlay, L., Paton, D. N., and Sharpe, J. S. Studies in the metabolism of rickets. *Quart. J. Med.*, 1920–21, xiv, 352–397.

Fletcher, H. M. Case of infantilism with polyuria and chronic renal disease. *Proc. Roy. Soc. Med.*, 1911, iv (*Sect. Dis. Child.*), 95.

Fletcher, H. M. Case of renal infantilism. *Brit. J. Child. Dis.*, 1920, xvii, 150. See also *Proc. Roy. Soc. Med.*, 1920, xiii (*Sect. Dis. Child.*), 118.

Foote, J. A. Evidence of rickets prior to 1650. *Am. J. Dis. Child.*, Sept., 1927, xxxiv, 443–452.

Förster, R. Ueber Schrumpfniere im Kindesalter. *Jahrb. f. Kinderh.*, 1887, xxvi, 38–43.

Fromme, A. Die Spätrachitis, die spätrachitische Genese sämtlicher Wachstums-Deformitäten und die Kriegsosteomalacie. *Ergebn. d. Chir. u. Orthop.*, 1922, xv, 1–203.

Giles, R. G. A study of rickets with review of recent literature. Am. J. Roentgenol. & Rad. Therapy, 1922, ix, 360–365.

Glisson. De Rachitide, 1660.

Goetsch, E. Abt's Pediatrics. W. B. Saunders Co., Philadelphia, 1924, iv, 757.

Goodhart, J. F. Cyclopedia Diseases of Children (Keating), 1872, iii, 556; also Chronic Bright's disease. Cyclopedia Diseases of Children (Keating), 1891, iii, 555.

Greene, C. H. Chronic diffuse nephritis in childhood. *Am. J. Dis. Child.*, 1922, xxiii, 183–209.

Hart, E. B. Steenbock, H., and Elvehjem, C. A. Dietary factors influencing calcium assimilation; effect of light upon calcium and phosphorus equilibrium in mature lactating animals. *J. Biol. Chem.*, 1924, lxii, 117–131.

Henderson, J. Case of advanced chronic interstitial nephritis in girl of ten years. *Glasgow M. J.*, 1923, xcix, 370–376.

Hess, A. F. Influence of light on rickets. *Lancet*, 1922, ii, 367–369.

HESS, A. F. Rickets. Abt's Pediatrics, W. B. Saunders Co., Philadelphia, 1923, ii, 907.
HESS, A. F. On the induction of antirachitic properties in rations by exposure to light. *Science*, 1924, lx, 269.
HESS, A. F., and GUTMAN, M. B. Cure of infantile rickets by sunlight, accompanied by an increase in inorganic phosphate of blood. *J. Am. M. Ass.*, 1922, lxxviii, 29–31.
HESS, A. F., and LUNDAGEN, M. A. Seasonal tide of blood phosphate in infants. *Proc. Soc. Exper. Biol. & Med.*, 1921–22, xix, 380–382.
HESS, A. F., and LUNDAGEN, M. A. Seasonal tide of blood phosphate. *J. Am. M. Ass.*, 1922, lxxix, 2210–2212.
HESS, A. F., MCCANN, G. F., and PAPPENHEIMER, A. M. Experimental rickets in rats; failure of rats to develop rickets on a diet deficient in vitamine A. *J. Biol. Chem.*, 1921, xlvii, 395.
HESS, A. F., and UNGER, L. J. Prophylactic therapy for rickets in a negro community. *J. Am. M. Ass.*, 1917, lxix, 1583.
HESS, A. F., and UNGER, L. J. The diet of the negro mother in New York City. *J. Am. M. Ass.*, 1918, lxx, 900.
HESS, A. F., and UNGER, L. J. Clinical rôle of fat-soluble vitamin; its relation to rickets. *J. Am. M. Ass.*, 1920, lxxiv, 217.
HESS, A. F., and UNGER, L. J. Cure of infantile rickets by sunlight. *J. Am. M. Ass.*, 1921, lxxvii, 39.
HESS, A. F., and UNGER, L. J. Infantile rickets; significance of clinical, radiographic and chemical examinations in its diagnosis and incidence. *Am. J. Dis. Child.*, 1922, xxiv, 327–338; also *Trans. Am. Pediat. Soc.*, 1922, xxxiv, 209.
HESS, A. F., and UNGER, L. J. Use of carbon arc light in prevention and cure of rickets. *J. Am. M. Ass.*, 1922, lxxviii, 1596–1598.
HESS, A. F., UNGER, L. J., and PAPPENHEIMER, A. M. A further report on the prevention of rickets in rats by light rays. *Proc. Soc. Exper. Biol. & Med.*, 1921–22, xix, 238.
HESS, A. F., and WEINSTOCK, M. Experiments on the action of light in relation to rickets. *Trans. Am. Pediat. Soc.*, June, 1924; also *Am. J. Dis. Child.*, 1924, xxviii, 517.
HESS, A. F., and WEINSTOCK, M. Imparting antirachitic properties to inert substances by ultra-violet irradiation. *J. Biol. Chem.*, 1925, lxiii, 207–304.
HESS, A. F., and WEINSTOCK, M. A further report on imparting antirachitic properties to inactive substances by ultra-violet irradiation. *J. Biol. Chem.*, 1925, lxiii, xxv–xxvi.
HESS, A. F., and WEINSTOCK, M. Antirachitic value of irradiated cholesterol and phytosterol; further evidence of change in biological activity. *J. Biol. Chem.*, 1925, lxiv, 181–191.
HESS, A. F., and WEINSTOCK, M. Antirachitic value of irradiated cholesterol and phytosterol; evidence of chemical change as shown by absorption spectra. *J. Biol. Chem.*, 1925, lxiv, 193–201.
HESS, A. F., WEINSTOCK, M., and HELMAN, F. D. Antirachitic value of irradiated phytosterol and cholesterol. *J. Biol. Chem.*, 1925, lxiii, 305–308.
HESS, A. F., WEINSTOCK, M., and HELMAN, F. D. Oil activated by irradiation. II. Separation into an antirachitic and an inactive fraction. *Proc. Soc. Exper. Biol. & Med.*, 1924–25, xxii, 76.
HESS, A. F., WEINSTOCK, M., and SHERMAN, E. Antirachitic value of irradiated cholesterol and phytosterol; factors influencing its biological activity. *J. Biol. Chem.*, 1925, lxvi, 145–160.
HESS, A. F., WEINSTOCK, M., and SHERMAN, E. Antirachitic value of irradiated cholesterol and phytosterol; chemical and biological changes. *J. Biol. Chem.*, 1926, lxvii, 413–423.
HESS, A. F., WEINSTOCK, M., and SHERMAN, E. Antirachitic value of irradiated cholesterol; separation into active and inactive fraction. *J. Biol. Chem.*, 1926, lxx, 123–127.
HESS, A. F., and WINDAUS, A. Contaminating substances as factor in activation of cholesterol by irradiation. *Proc. Soc. Exper. Biol. & Med.*, 1927, xxiv, 369–370.
HILL, L. W. Studies in nephritis of children. *Am. J. Dis. Child.*, 1919, xvii, 270.
HOLMES, G. W. Osteomalacia, its roentgenographic appearance and classification. AM. J. ROENTGENOL., 1918, v, 507.
HOLT, L. E., COURTNEY, A. M., and FALES, H. L. Calcium metabolism of infants and young children, and relation of calcium to fat excretion in stools. *Am. J. Dis. Child.*, 1920, xix, 97 and 201.
HOWLAND, J. Etiology and pathogenicity of rickets. *Medicine*, 1923, ii, 349–374.
HOWLAND, J., and KRAMER, B. Calcium and phosphorus in serum in relation to rickets. *Am. J. Dis. Child.*, 1921, xxii, 105.
HOWLAND, J., and KRAMER, B. Factors concerned in the calcification of bone. *Proc. Am. Pediat. Soc.*, 1922, xxxiv, 204.
HULDSCHINSKY, K. Die Behandlung der Rachitis durch Ultraviolettbestrahlung Dargestellt an 24 Fällen. *Ztschr. f. orthop. Chir.*, 1919–20, xxxix, 426–451.
HUNT, F. C. Renal infantilism. *Am. J. Dis. Child.*, August, 1927, xxxiv, 234–248.
HUTCHISON, H. S., and SHAH, S. J. The aetiology of rickets, early and late. *Quart. J. Med.*, 1921–22, xv, 167–194.
HUTCHISON, H. S., and STAPLETON, G. Late rickets and osteomalacia. *Brit. J. Child. Dis.*, 1924, xxi, 18–33; 96–106.
KARSNER, H. T. Congenital nephritis. *Proc. Path. Soc. Phila.*, 1909, xii, 16.
KENDALL, G. M. Renal dwarfism? *Proc. Roy. Soc. Med.*, 1923, xvi (*Sect. Dis. Child.*), 20.
KRAMER, B. Rickets in infants; treatment with irradiated milk. *Am. J. Dis. Child.*, 1925, xxx, 195–198.
LATHROP, F. W. Renal dwarfism. *Arch. Int. Med.*, 1926, xxxviii, 612–622.
LEWIN, P. Adolescent rickets. *Surg., Gynec. & Obst.*, 1922, xxxv, 77–83.
LUCAS, R. C. Form of late rickets associated with albuminuria, rickets of adolescents. *Lancet*, 1883, i, 993–994.
LYON, G. *Lancet*, 1901, i, 102.
MCCOLLUM, E. V., SIMMONDS, N., PARSONS, H. T., SHIPLEY, P. G., and PARK, E. A. Studies on experimental rickets; production of rachitis and similar diseases in rat by deficient diets. *J. Biol. Chem.*, 1921, xlv, 333.
MCCOLLUM, E. V., et al. Experimental rickets; production of rickets by diets low in phosphorus and fat-soluble A. *J. Biol. Chem.*, 1921, xlvii, 507.
MARRIOTT, W. M., and HOWLAND, J. Phosphate retention as a factor in the production of acidosis in nephritis. *Arch. Int. Med.*, 1916, xviii, 708–711.
MELLANBY, E. Medical Research Committee, Report No. 38, London, 1919.
MELLANBY, E. An experimental investigation on rickets. *Lancet*, 1919, i, 407.
MELLANBY, E. Deficiency diseases, with special reference to rickets. *Brit. M. J.*, 1924, i, 895–900.
VON MEYSENBUG, L. Recent phases of rickets problem. *South. M. J.*, 1926, xix, 522–526.
VON MEYSENBUG, L., and others. Diffusible calcium of blood serum; method for its determination. *J. Biol. Chem.*, 1921, xlvii, 529.

von Meysenbug, L., and McCann, G. F. Diffusible calcium of blood serum; human rickets and experimental dog tetany. *J. Biol. Chem.*, 1921, xlvii, 541.

Miles, L. M., and Feng, C. T. Calcium and phosphorus metabolism in osteomalacia. *J. Exper. M.*, 1925, xli, 137–157.

Miller, R. Chronic interstitial nephritis with infantilism. *Proc. Roy. Soc. Med.*, 1911, v (*Sect. Dis. Child.*), 38.

Miller, R., and Parsons, L. Renal infantilism. *Brit. J. Child. Dis.*, 1912, ix, 289–304.

Naish, A. E. Infantilism with chronic interstitial nephritis. *Brit. J. Child. Dis.*, 1912, ix, 337–343.

Ogilvie, W. H. Case of renal dwarfism. *Proc. Roy. Soc. Med.*, 1923, xvi (*Sect. Orthop.*), 51.

Orr, W. F., Holt, L. E., Jr., Wilkins, L., and Boone, F. H. Calcium and phosphorus metabolism in rickets, with special reference to ultraviolet ray therapy. *Am. J. Dis. Child.*, 1923, xxvi, 362–372.

Page, C. M. Case of renal dwarfism. *Proc. Roy. Soc. Med.*, 1921, xiv, 89.

Pappenheimer, A. M. Experimental rickets in rats; anatomical changes which accompany healing of experimental rat rickets under influence of cod liver oil or its derivatives. *J. Exper. M.*, 1922, xxxvi, 335–355.

Parsons, L. Infantilism associated with chronic interstitial nephritis. *Brit. M. J.*, 1911, ii, 481.

Paterson, D. H. Three cases of renal dwarfism associated with curious bony changes. *Proc. Roy. Soc. Med.*, 1920, xiii (*Sect. Dis. Child.*), 107.

Paterson, D. H. Renal dwarfism with bony changes. *Brit. J. Child. Dis.*, 1921, xviii, 186–188.

Paterson, D. H. Renal dwarfism. *Lancet*, 1922, i, 944.

Porter, L. Renal infantilism. *Arch. Pediat.*, 1915, xxxii, 85–91.

v. Recklinghausen, F. Die Fibröse oder deformierende Ostitis, die Osteomalacie und die osteoplastische Carcinose, in ihren gegenseitigen Beziehungen. *Festschr. R. Virchow, Berlin*, 1891, i.

Roth, P. B. Case of renal dwarfism shown after operation for genu valgum. *Proc. Roy. Soc. Med.*, 1923, xvi (*Sect. Orthop.*), 45.

Sawyer, J. E. H. Chronic interstitial nephritis in children. *Birmingh. M. Rev.*, 1903, ii, 511; 549.

Schabad, J. A. Der Phosphor in der Therapie der Rachitis; der Einfluss des Phosphors auf den Kalkstoffwechsel bei rachitischen und gesunden Kindern. *Ztschr. f. Klin. Med.*, 1908–09, lxvi, 454–494.

Schabad, J. A. Die Behandlung der Rachitis mit Lebertran, Phosphor und Kalk; ihr Einfluss auf den Kalk- und Phosphorstoffwechsel bei Rachitis. *Ztschr. f. klin. Med.*, 1909, lxviii, 94–110.

Schabad, J. A. Phosphor, Lebertran und Sesamöl in der Therapie der Rachitis; ihr Einfluss auf den Kalk, Phosphor-, Stickstoff- und Fettstoffwechsel. *Ztschr. f. klin. Med.*, 1910, lxix, 435–474.

Schwarz, Herman. Kidney diseases in infants and children. *Am. J. Dis. Child.*, 1924, xxvii, 233–242.

Sherman, H. C., and Pappenheimer, A. M. Experimental rickets in rats; diet producing rickets in white rats, and its prevention by addition of an inorganic salt. *J. Exper. M.*, 1921, xxxiv, 189.

Sherman, H. C., and Pappenheimer, A. M. Experimental rickets in white rats, and its prevention by the addition of an inorganic salt. *J. Exper. M.*, 1921, xxxiv, 189; *Proc. Soc. Exper. Biol. & Med.*, 1921, xviii, 193.

Shipley, P. G., Kramer, B., and Howland, J. Calcification of rachitic bones in vitro. *Am. J. Dis. Child.*, 1925, xxx, 37–30.

Shipley, P. G., Park, E. A., McCollum, E. V., and Simmons, N. Is there more than one kind of rickets? *Am. J. Dis. Child.*, 1922, xxiii, 91–106.

Smith, D. C. W., and Walsh, M. D. Rickets and subsequent dwarfism associated with renal disease; report of case. *South. M. J.*, June, 1927, xx, 437–440.

Steenbock, H. The induction of growth promoting and calcifying properties in a ration by exposure to light. *Science*, 1924, lx, 224.

Steenbock, H., and Black, A. Fat-soluble vitamins; induction of growth-promoting and calcifying properties in ration by exposure to ultra-violet light. *J. Biol. Chem.*, 1924, lxi, 405–422.

Steenbock, H., and Black, A. Fat-soluble vitamins; induction of growth-promoting and calcifying properties in fats and their unsaponifiable constituents by exposure to light. *J. Biol. Chem.*, 1925, lxiv, 263–298.

Steenbock, H., and others. Antirachitic activation by light. *J. Biol. Chem.*, 1925, lxiii, xxv.

Steenbock, H., and Nelson, M. T. Fat-soluble vitamins; induction of calcifying properties in a rickets-producing ration by radiant energy. *J. Biol. Chem.*, 1924, lxii, 209–216.

Still. Common Disorders and Diseases of Childhood. Oxford University, Press, Ed. 4. 1924, 598.

Sutherland, G. A. Case of infantilism. *Proc. Roy. Soc. Med.*, 1911, v, (*Sect. Dis. Child.*), 3; also Case of extreme rickets and infantilism, *Ibid.*, 5.

Telfer, S. V. Calcium and phosphorus metabolism; excretion of calcium and phosphorus. *Quart. J. Med.*, 1922, xvi, 45–62; also calcium and phosphorus metabolism; metabolism of calcium and phosphorus in rickets. *Ibid.*, 63–72.

Watson-Wemyss, H. L. Chronic interstitial nephritis in childhood: renal infantilism (?) *Edinb. M. J.*, 1922, xxix, 300–305.

Weber, F. P. Diabetes insipidus in a boy with positive Wassermann reaction; remarks on polyuria in children and infantilism. *Brit. J. Child. Dis.*, 1912, ix, 211.

Zucker, T. F. The relation of acid base equilibrium in the body to excretion of phosphorus and calcium. *Proc. Soc. Exper. Biol. & Med.*, 1921, xviii, 272.

Zucker, T. F., Johnson, W. C., and Barnett, M. The acid base ratio of the diet in rickets production. *Proc. Soc. Exper. Biol. & Med.*, 1922, xx, 20.

Zucker, T. F. Further observations on the chemistry of cod liver oil. *Proc. Soc. Exper. Biol. & Med.*, 1922, xx, 136.

Zucker, T. F., Pappenheimer, A. M., and Barnett, M. Observations on cod liver oil and rickets. *Proc. Soc. Exper. Biol. & Med.*, 1921, xix, 167.

Zundel, C. E. Two cases of infantilism. *Proc. Roy. Soc. Med.*, 1913, vii (*Sect. Dis. Child.*), 1.

Vol. XVIII, No. 5

GASTRIC CARCINOMA

REPORT OF RARE COMPLICATION. ULCERATION FORMING NATURAL GASTROENTEROSTOMY*

BY HARRY OLIN, M.D.

CHICAGO, ILLINOIS

WHILE gastric carcinoma is relatively frequent, ulceration is a fairly common occurrence. Ulceration into a neighboring organ and especially any abdominal viscus has been noted and there are many such frequent reports in the literature. Ulceration into the gall-bladder forming a fistula between the stomach and the organ has been cited by Carman and was discovered in the routine course of a gastrointestinal opaque meal. Here the barium was visualized passing from the stomach into the gall-bladder and the new fistulous pocket could be emptied and filled.[1]

A perusal of the literature mentions a few cases of gastric carcinoma followed by ulceration and forming a fistula with the jejunum resulting in a natural gastroenterostomy as if the process were surgically performed. Because of this apparent rarity as a complication of gastric carcinoma the following case is reported.

CASE REPORT

E. C., female, aged seventy, married.

Marital History. Had three children, two of whom are living and well. One died of scarlet fever, aged ?.

Past History. The patient has always enjoyed very good health. Up to six years ago she lived in New Jersey with one of her children. At that time she had numerous attacks of indigestion and vomiting spells but after a time she improved and felt quite well up to six or seven months ago when she noticed loss of flesh and gradually increasing weakness. She has lost 30 pounds in the last seven months. The patient has lost her appetite for meats but is able to take a fair amount of milk, cereals and vegetables. At the present time she is inclined to melancholia. Physical examination was essentially negative. No tumor mass could be felt. (Superficial examination by Dr. Rud.)

The patient reported to the hospital for one roentgen observation and her family physician was unable to persuade her to enter the hospital for further observation and care. She died three or four months later, so I was informed by her doctor, and during that time was apparently in a comfortable condition. No further history or other data could be obtained by her doctor since the patient returned to her daughter's home in New Jersey.

Roentgen-ray Report. Roentgen examination of the gastrointestinal tract reveals definite irregularity with some delay at the lower end of the esophagus which is somewhat dilated. The stomach appears definitely irregular at the junction of the vertical with the horizontal portions at the greater curvature, and with ingestion of the meal the food passes rapidly into the stomach and then over into the jejunum through what apparently appears as a stoma. The food does not remain in the stomach sufficiently long to outline the organ entirely but the irregularity of the greater curvature is seen in practically all positions with ingestion of the second glass of barium mixture. Practically the entire jejunum can be visualized, the greater portion of which is dilated and there is a large loop which can be seen transversely across the abdomen. The duodenal bulb can be seen and food was observed passing through this area.

The above findings are indicative of an extensive neoplasm of the stomach with rupture into the jejunum through the stoma caused by the ulceration of the tumor mass forming a natural gastroenterostomy. (This patient never had an abdominal operation.) A further study of the progress of this meal would reveal the condition of the large bowel. Ulceration with the presence of an inflammatory mass cannot be excluded.

Findlay and Findlay report a case of gastric carcinoma in which large quantities of blood were vomited and in which after death a gastrojejunal fistula was found. The authors state that ulcerative communications in gastric carcinoma between the stomach and colon, and stomach and skin, or stomach and peritoneum are not very uncommon, but a fistula between the stomach and small intestine is very rare indeed. "So far we have obtained reference to three cases in which the last men-

* X-ray Department, West Suburban Hospital, Oak Park, Illinois.

tioned condition was found and curiously enough in all, the cancer was at the pylorus and there was an urgent necessity for such short circuiting. In our case the pylorus was not involved and no need existed for this naturally contrived gastroenterostomy. This patient was under observation for four months and size of tumor was inhibited."[2]

In the case now reported the body of the stomach in its mid portion was involved and the fistulous stoma while irregular, functioned very satisfactorily.

Fig. 1. Gastric carcinoma. Ulceration into jejunum forming natural gastroenterostomy. Note rapid emptying of stomach and dilated loops of ileum. Immediate meal.

Ulceration into the small intestine but not the jejunum is another record of a case of gastric carcinoma perforating into the duodenum and which bears some resemblance to this case. This, however, was a post-mortem finding.[3]

In roentgenoscopy of a colon some years ago in which a large abdominal mass was found in the left upper quadrant, a communication was found between the splenic flexure and ileum, and this observation of the writer was confirmed by three subsequent studies and operation but no report was ever published. References such as these in the literature, that is, ulceration of colon carcinoma forming fistulae with the small bowel are not infrequent and have been reported, but the rarity of ulceration of gastric carcinoma forming a natural gastroenterostomy (gastrojejunostomy in this case) has justified a report of this case.

COMMENT

A woman of seventy having an extensive carcinoma of the stomach and which ulcerated through into the jejunum, forming a natural gastroenterostomy is a rare complication of malignancy. That the ulcerative anastomosis healed sufficiently to form a functioning stoma, there can

Fig. 2. Gastric carcinoma. Immediate meal. Ulceration through gastric wall into jejunum forming natural gastroenterostomy. No operation. Note barium discharging through newly formed stoma and through duodenum.

be no doubt as confirmed and seen both by roentgenoscopy and a study of the films. The striking features of this gastric carcinoma were: (1) the apparent comfort of the patient, and (2) no history of vomiting blood. The patient exhibited no abdominal scars and furthermore claims never to have had any operation. It is possible that seven or eight months ago during a severe vomiting attack, she developed a fistulous opening between the stomach and jejunum and while not claiming to have vomited blood the stools, in all probability, con-

tained digested blood. In any event she was in apparent comfort with this newly formed stoma. The rapid emptying of the barium meal through the stoma did not afford an opportunity for a complete survey of the stomach in all planes. In view of the patient's loss of weight, the gradually progressing weakness and the extensive roentgen findings the logical conclusion reached was that the case was one of gastric carcinoma complicated by ulceration into the small intestine forming a natural gastroenterostomy.

Many thanks are due Dr. Anthony Rud of Chicago for kindly furnishing the history and referring the case to me.

REFERENCES

1. CARMAN, R. D., and MILLER, ALBERT. The Roentgen Diagnosis of Diseases of the Alimentary Canal. W. B. Saunders Co., Philadelphia, 1917.
2. FINDLAY, W., and FINDLAY, J. W. Case of cancer of the stomach, in which large quantities of blood were vomited, and wherein after death was found a gastro-jejunal fistula. *Glasgow M. J.*, 1906, lxv, 54–57.
3. BIGGS, G. P. Cancer of the stomach and perforation of the duodenum. *Med. Record*, 1893, xliv, 826.

ROENTGENOGRAPHY IN PROGNOSIS OF PULMONARY TUBERCULOSIS

BY A. G. SCHNACK, A.M., M.D.

HONOLULU, HAWAII

THE very nature and variability of tuberculosis makes it impossible to prognosticate with any great degree of certainty in any special case, but broad principles may be laid down which will help us foresee the future course of the disease. Opinions as to prognosis are quite divergent, some claiming very little and others a great deal from the roentgenographic plate. Roentgenological interpretation of pulmonary tuberculosis has begun to attain scientific standards only within the last decade, and we have only within the last five years or so produced roentgenograms which show sufficiently fine detail to make possible the finer diagnoses demanded at this time.

There are numerous invaders of the human system and each invader, whether bacterial or parasitic, calls forth a somewhat different body protective response. Most of such invasions have not appealed to the interest or imagination of so many investigators as tuberculosis has. The fundamental principle to be kept in mind is that tuberculosis is a disease resulting from the invasion by the tubercle bacillus and that one must think of it as being different but similar to the body response to numerous other invasions, and that we must be impressed by the similarity of these body reactions rather than attempt to segregate any one of these as has been done with tuberculosis.

My object in this article is not to attempt the impossible but merely to present some general principles which I have found most often correct in the prognosis of a tuberculous condition as seen in the roentgenographic plate. (I shall avoid roentgenoscopic findings.) Except in outspoken cases the careful attitude of the internist in considering all possibilities is the one that is least apt to lead us into error. I prefer to deal more with generalities rather than attempt to differentiate the various forms of this disease into too fine a classification. A developing hypersensitiveness or a superimposed complication, as we know, may necessarily alter our classification of a particular case within a very short time.

It is almost impossible to try to prognosticate without giving some sort of differential diagnosis even though we omit or treat very casually some forms of tuberculosis which are of importance. The individual "reaction" factor must always be considered. All persons do not react constitutionally in the same way to similar

degrees of infection. The individual variation in hypersensitiveness to different infections as we know is most marked. We know that often the advanced, undoubtedly fatal tuberculous cases may appear robust and enjoy considerable comfort, while the mildly involved ones may show marked symptoms of collapse.

Our prognosis depends in great part on a clear conception of the disease process. The disease tuberculosis is an inflammatory one. Our pathologists explain inflammation as, "A complicated vascular and cellular response following injury and is adapted by bringing much blood to the spot and pouring out its elements upon the injured tissues to prevent extension of the injury, hold in check the injurious agent, or even destroy it. Through the agency of some of the cells which are brought in and in other purely mechanical ways it is also concerned in clearing away the debris of injured or dead tissue and preparing the way for the process of repair."[1] That every inflammatory process is a body protective response whether it be diffuse or localized cannot be denied. Throughout the body there is always an attempt to remove the offending agent. This is generally attempted by encapsulation (fibrosis and calcification), by digestion and absorption, or by expulsion of the infective material, or by all three means. The various elements that go to make up body immunity naturally aid these processes. Whether it be a pericarditis, pneumonitis, abscess, catarrhal condition, etc., expulsion of the infective material is in the direction of least resistance. Rapidly forming adhesions between pleural and peritoneal surfaces prevent more frequent spreading of infection through the body cavities, and for this reason we frequently see deep infections discharging externally or indirectly so through the gastrointestinal tube, bladder, etc., or as in the chest, through the bronchi.

It is generally conceded that the ability of the lung tissue to produce reticulum with subsequent fibrosis or calcification about a tuberculous area is an important index of the fighting qualities of the body. As I have previously mentioned,[2] our symptoms in any case depend in great measure upon the vascularity of the infected area, and the avascularization of this area through fibrosis, etc., is the means of lessening toxic absorption. The fibrosis itself is but an imperfect mechanical barrier to bacterial dissemination. A large exudative area about a tuberculous focus conversely means much vascularity and a high degree of allergy. This hypersensitiveness, manifesting itself by flare-ups following reinfection or stimulation by nonspecific means, can easily account for the exudation about a focus without needing to explain it on the basis of secondary invaders about the tuberculous area. In a small series of 10 cases of tuberculosis with extensive exudative reactions, lung punctures were made to determine the presence of any secondary invaders in numbers sufficiently large to be recognized in Gram-stained smears. Such lesions, located on the lateral chest margin, as determined by the roentgenographic plate, could easily be punctured by a large needle attached to a syringe and the material spread on a clean glass slide. The usual adhesions between visceral and parietal pleura make the procedure harmless. Cultures might have revealed the presence of secondary organisms, but if they were too few to recognize in a smear, as was the case in all 10 of our lung punctures, they could hardly be responsible for the marked exudative reactions. That the focal reaction may be stimulated by various chemical substances has been frequently shown. A secondary infection of tonsils, teeth, etc., has a stimulating effect on a tuberculous focal reaction. Fatigue, physical and nervous, stimulates the tuberculous focal reaction. A hypersensitiveness to the split products of the tubercle bacillus protein is no doubt specific, but a similar, perhaps not so marked reaction when allergy is well established, may be evoked by nonspecific means. A point I wish to emphasize is that we have outside factors to consider when viewing the exudative reaction about a tuberculous focus. Is the reaction exudate a new area of infection, is it a reactivation of an older area stimulated by a tuberculous reinfection, is it a stimulation by an upper respiratory or other non-tuberculous infection, or by any other nonspecific agent? New areas of infection will naturally, because of their comparative

vascularity, show a greater perifocal reaction than the older more fibrosed areas. When we have nonspecific agents for the stimulation of a tuberculous area we should look for quick subsidence of the reaction with removal of or clearing up of the source of irritation. It behooves us therefore not to be too hasty in making a prognosis of the lesions by the roentgenographic appearance. It may be quite humiliating to see apparently serious cases suddenly clear up roentgenographically and symptomatically on the drainage of a sinus or the removal of an infected tonsil.

Tissue necrosis results to a greater or lesser degree from the inflammatory reaction. The exact explanation of the events can only be surmised. The resulting picture may show numerous variations even with the same offending agent. Possibilities, as cell death from exotoxins or toxins liberated or produced from bacterial digestion, or from cellular products modified by the unusual environment, cell death resulting from auto-digestion products or from asphyxiation, must be considered. Whatever the series of events the object of the process, on the whole, is a protective one, not merely destructive and purely harmful.

We very frequently see evidences of similar degrees of activity in both chests as we would naturally expect. The extent of involvement of both chests or of different areas in the same chest may vary, but the response to existing infection is, for the most part, similar for areas that have become involved at about the same time. The subsequent exudative reaction about these areas following reinfection or other stimulation should also be of equal intensity. This establishes a sort of guide as to the comparative age of the various chest lesions. Our primary infection, without doubt, has an indirect effect on the exudative reaction of subsequent reinfections. This effect diminishes as the avascularization of the primary infection proceeds and allergy diminishes. In tuberculosis we should view all the so-called "degrees of activity" from the viewpoint of body response to infection. In the more inflammatory tuberculous reactions we find a variable prognosis, depending in part upon the extent of the invasion. Barring unusual complications or associated infections and diseases, an optimistic prognosis can usually be given when the lesion is confined to a small area. When such a patient receives adequate rest and the other adjuvants of treatment we can generally look for rather rapid disappearance of the evidence of an irritative lesion. When the lung involvement is more extensive, the allergic reaction with its associated increased vascularity may cause a too rapid absorption of the focal products which may be more than the system can handle and so result in complete collapse of the defensive mechanism and further spreading of the disease. With the acute inflammatory processes it often seems to be a question of acute collapse from toxic absorption, or, on the other hand, of rapid, practically complete recovery. The less exudative processes where we can often recognize the innumerable conglomerate miliary tubercles which go to make up the inflammatory area, although often symptomatically mild may proceed to enlarge and advance to certain fatality. When the body has evacuated a tuberculous area, or encapsulated it, the reaction, focal and systemic, becomes less. Cavitation when not too extensive would be perhaps the quickest and best way to eliminate infection, but in a certain proportion of these cases where the vascular supply has not become thoroughly thrombosed, we may have a serious hemorrhage. As a rule we find after the necrotic material from the walls of the cavity has been eliminated that the encapsulating fibrous tissue through shrinkage is capable of practically completely eliminating the cavity. Again, probably from inability to react with sufficient fibrosis, the cavity may extend beyond its fibrosing limits and result in the further loss of more or less healthy living tissue. This may be in part due to secondary invaders usually present at this stage. Why one tuberculous lung area should ulcerate with cavity formation while another fibroses can perhaps be in part explained by the histological findings given in an article by Miller.[3] He shows that in tuberculous pneumonic patches we may have three different kinds of tissue response:

1. The walls of the alveoli are not recog-

nizable and the exudate caseates rapidly. There are very few tubercles and no reticulum is found in the alveoli.

2. The walls of the aveoli are thickened. There is an increase in the reticulum of the walls but very little reticulum in the alveoli. The alveoli are filled with exudate and caseation takes place early. There are many miliary tubercles and there is a tendency to encapsulate caseous areas.

3. Alveolar walls are thickened and there is an exudate in the alveoli of endothelial cells, lymphocytes, and some polymorphonuclears all in a dense net work of reticulum. This reticulum is not only in the alveolar walls but is invading the alveoli. There are numerous miliary tubercles. Reticular tissue is as resistant as elastic tissue. It would seem logical to assume that only the first two types (the more exudative types) could produce cavitation recognizable in the roentgenographic plate.

Peribronchial tuberculosis except as a lymphatic extension from the lung parenchyma or hilum offers great difficulty in diagnosis. A patch of parenchymal involvement located in the paraspinal fossa or near the sternal border may give the erroneous impression of a true peritruncal affair. With dense lesions one cannot always be certain even with stereo views. Any pathological hilum change may produce thickening of the perihilum markings. A luetic infection may extend outward from the hilum, and other spirochetal and fungoid organisms may produce a similar picture. Bronchopneumonia, bronchitis, asthma, bronchiectasis, vascular stasis, etc., may also produce a confusing picture. Our prognosis, therefore, generally speaking, is of doubtful value.

Whether our primary infection is parenchymal or of the hilum is of little moment. It has been shown that the endothelial leucocyte is probably the most frequent agent in the removal of tubercle bacilli reaching the neighborhood of the lungs and that the organisms are brought into the lymphatic system where they are usually held up by lymphoglandular tissue where bacterial and tissue proliferation continues. There is very soon, if not at first, a lymph node infection manifesting itself by swollen lymph nodes. Depending upon the degree of the reaction in and about these swollen nodes which may be augmented by irritation directly or indirectly from secondary invaders we will have varying degrees of tissue necrosis within the node which may discharge at various points, (bronchi, suprasternal notch, pericardium, etc.), or the process may fibrose and calcify. If the primary infection occurs late in life, as occurs occasionally with isolated people, the nodal swelling may be great, and may be associated with a markedly proliferative pleuritis which may prove fatal. It is remarkable that a great deal of nodal infection in childhood may be associated with only the mildest symptoms, and if extension into the lung parenchyma does not occur, the infection may be compatible with a state of fairly good health. Although the total amount of lymphoid tissue, especially in the follicles of the lung, is increased with age, there is more blockage of the lymphatic system and we find less general nodal involvement from a localized infection. The diagnosis of a hilum tuberculosis is often difficult and probabilities are often arrived at only by considering the family history, the course of events, involvement of portions of the lung parenchyma and clinical tests. In very small children calcification of the nodes and lymph follicles serves to partially differentiate a tuberculous nodal infection, but only after the condition has existed for some time. Occasionally individual swollen nodes may be recognized in the roentgenographic plate. Upper respiratory infections, typhoid fever, acute bronchitis and numerous other conditions may give nodal swelling, a clouded thickened hilum and a confusing picture.

Fibroid phthisis, so-called because of the existence of a dense fibrosis involving one or more large areas, often coexists with other areas of more active lung tuberculosis. Fibrosis resulting from other non-tuberculous lung lesions like unresolved pneumonia, lung abscess cavities, etc., may give difficulty in differential diagnosis. The functional loss of much lung tissue, together with the associated chest deformity and visceral embarrassment are a disadvantage when considering a superimposed infection of any kind.

We very frequently see a very widespread fibrosis of a less dense character associated with a slight furring and beading of the parenchymal lung markings and hilum changes. This represents a widespread tuberculous infection but with very little tissue reaction. At times it is difficult to make out any definite exudate whatever and the patient may show very few symptoms. Tuberculous reinfection, upper respiratory infections, fatigue, etc., may stir up signs of activity both in the plate and in the way of physical signs and symptoms. Flattening of one or both chests with signs and symptoms of being "below par" are the usual rule. Because of the widespread character of the infection we feel justly solicitous about the patient. The lack of a generous fibrosis tends to keep the lesions somewhat open and liable to metastasis, and shows a lack of fighting ability. Such patients may with care live fairly normal lives but are always in danger. The course of events may suddenly terminate by various routes. These cases often beginning in early childhood receive the roentgenographic report that "there is a fibrosis of one or both upper chests, with hilum thickening and perhaps calcification, which shows no definite evidence of activity but considering the age of the patient, the fibrous and other lung changes, and the patient's general appearance and history we believe the process not entirely quiescent." Following such a patient we may see a gradually spreading fibrosis without any more definite signs of activity. In old age the fibrotic tissue radiating outward from the hilum is normally increased, and in cases of general arteriosclerosis we find a uniform sclerosis of the entire lung field and hilum. Such a condition would naturally confuse us when attempting to differentiate areas of tuberculosis with slight exudative reactions, especially when we find evidence of healed tuberculous lesions.

A true tuberculous pneumonia is rather infrequent and is generally due to massive infection through aspiration into the bronchi of one or more lobes with allergy well established.[4] The prognosis because of the great involvement, with further danger from metastasis and secondary complications is usually poor, although such patients do occasionally recover.

In miliary tuberculosis a blood stream infection is the rule and here the prognosis is generally poor, although not always hopeless. We very frequently find a rather mild reaction about the tubercles. Whether the scant reaction exudate is due to the comparatively small number of bacilli at any one point, or whether it often occurs when allergy is low is problematical. It has been thought that erosion into a blood vessel occurs only when the defensive mechanism has collapsed, and the exudative reaction may be scant for the same reason.

Concluding, I may briefly emphasize that although the tubercle bacillus, because of specific characteristics, calls forth certain definite body responses to its invasion, there are certain broad principles which govern these responses which are similar to those involved with other invaders. The body responses to infections are such as produce the best results in the great majority of such infections. Such body responses it would seem, in certain cases, are perhaps not the most economical method of fighting the infection. Overactivity of the reaction may be distinctly harmful, especially when the infection is widespread. So much in tuberculosis remains unproven that we can often speak only in general terms, which should be judged leniently. Most of the above principles are not new; those that are, are offered for consideration.

REFERENCES

1. MacCallum, W. G. A Text-Book of Pathology. Second edition. W. B. Saunders, Philadelphia.
2. Schnack, A. G. The hilum in tuberculosis. Am. J. Roentgenol. & Rad. Therapy, 1926, xv, 424–430.
3. Miller, Wm. Snow. Studies on the normal and pathological histology of the lung. *Am. Rev. Tuberc.*, 1925, xi, 1–18.
4. Lord, F. T. Diseases of the Bronchi, Lungs and Pleura. P. 209.

A REPORT ANALYZING THE RESULTS OF THE QUESTIONNAIRE SENT OUT TO RADIOLOGISTS, UNDER THE DIRECTION OF THE SEX COMMITTEE OF THE NATIONAL RESEARCH COUNCIL

BY P. M. HICKEY, M.D., AND E. W. HALL, M.D.

ANN ARBOR, MICHIGAN

DURING 1925, the Committee for Research in Problems of Sex, appointed by the Division of Medical Sciences of the National Research Council, sent out a questionnaire to a number of radiologists in the United States and Canada. The questionnaire was divided into the following subdivisions: Form A was written with the idea of determining if sex changes take place in mothers, either by roentgen-ray exposure before or during pregnancy; Form B was framed to determine if roentgen-ray exposures before or during pregnancy produced changes in the fetus; Form C was designed to elicit information regarding changes in the sex life of those practicing roentgenology. The following paper is an attempt to classify the replies to these questionnaires.

The spirit of coöperation in making out the replies to the various questions was quite striking, and on behalf of the committee, we would express the committee's thanks to those who responded to the invitation. The information obtained is of considerable value and forms a very creditable beginning in the collection of statistics on these interesting questions. It is hoped that the publication of this report will pave the way for future and more comprehensive investigations.

Form A. The replies to Form A give some data on the effect of diagnostic and therapeutic exposures on the sex life of the mother. The answers comprised 79 cases. Of these, 24 detailed the results of diagnostic exposures and 55 detailed the results of therapeutic exposures. The therapeutic exposures were subdivided into forty-six roentgen-ray exposures and nine radium exposures. The questionnaire endeavored to bring out the fact as to whether the reproductive organs were shielded during exposure. The answer showed that the reproductive organs were not protected in 58, that they were protected in 15, and 6 replies failed to give information on this desired point. In the 79 cases, the replies were explicit that in 56 cases there was no noticeable effect upon sexual desire; in 6 cases, the sexual desire was decreased. It was noted that in 2 cases there was a definite statement that sexual desire was increased. In 15 cases, there was no note made as to libido.

In the 55 therapy cases, it was noted that 34 were sterile after roentgen therapy, and 7 not sterile after therapy. Three of the cases that were not rendered sterile were reported to have had pelvic therapy. It is worthy of note that in the records of these cases where subsequently children were born, no abnormality was noted. Having considered in a general way the above classification, it might be advantageous to quote some of the individual experiences.

In one case, No. 8840, the patient received the customary erythema dose for purposes of sterilization but did not return for subsequent irradiation. She became pregnant a month later.

One roentgenologist reports the following 2 interesting cases: (1) patient, twenty-nine years of age, married for ten years without conception, was very desirous of bearing a child. She received treatments over the thyroid gland for hyperthyroidism. Six months after the treatments were given, the patient became pregnant and was delivered of a normal child at full term. This case is of interest in connection with the following case. (2) Patient, aged thirty-two, had been married five years without conception. She was given roentgen treatment for chronic hypertrophic follicular tonsillitis. One year after the conclusion of these treatments, she

became pregnant and was delivered of a normal child at full term. Another patient, aged thirty-one, was given treatments for carcinomatous glands of the neck and subsequently went through a normal pregnancy.

Another patient, aged twenty-nine, received roentgen treatment for mastitis of the right breast. This patient also went through a subsequent normal pregnancy and was delivered of a normal child.

Another patient, aged twenty-eight, was given deep roentgen therapy for carcinoma of the rectum. No attempt was made to protect the reproductive organs. Therapy produced no effect upon sexual desire.

The following case is interesting: Patient, aged twenty-five, in 1908 and 1909, had 124 roentgen treatments covering thirty-six areas, twelve anterior over the pubic region and twenty-four over the sacral region. The treatments were given for uterine fibroid and tuberculosis of the sacrum. The patient had complete epilation of the pubic hair, and menstruation ceased. Patient became pregnant four months before the last treatment was given in 1909. In May, 1910, she was delivered of a girl baby of normal size and of normal development. The patient is now forty-one years of age, menstruates regularly, and has never noticed any diminution of sexual desire. The child is now sixteen years of age and has never required a physician's care since birth. Her menstruation began at the age of thirteen and she is apparently entirely normal.

The 24 diagnostic cases were all reported by one radiologist. In none of the cases was there any effect noted on libido and no ill effects were reported on the fetus.

The following observation may be made on these 79 cases: (1) the detailed report shows no deleterious effects on the mother or fetus following diagnostic exposure of the pregnant uterus; (2) therapeutic roentgen-ray exposures of the superficial type are not usually followed by lessening of libido; (3) therapeutic exposures of the so-called deep therapy type are frequently followed by diminished sexual desire.

Form B. Form B was designed to bring out reports as to the effect of radiation upon the development of fetal structures. The replies can be subdivided into two groups: (1) reports on cases where diagnostic exposures were made; (2) reports on cases where radiation therapy was employed. There were individual reports on 76 cases where diagnostic exposures were made during pregnancy. Of these, 69 came to full term with normal delivery of a normal child. The 7 cases reported where normal delivery of a normal child did not take place, can be listed as follows: One case of induced labor at eight months for uremia, normal child. One case of still birth due to the size of the child. It was noted that the child was apparently normally formed. There was one miscarriage of twins, one of these was macerated in a manner which indicated that death had taken place before the diagnostic exposure had been made. There were 2 abortions and 2 monsters both of which had been diagnosed as monstrosities at the time of the examination of the roentgenograms. It would therefore seem that the use of diagnostic exposures as predicated by this group is not attended with danger to the fetal structures.

There were 12 detailed reports on therapy cases where radiation had been employed and where the pregnancies were followed to full term. These are tabulated as follows: One case treated for menorrhagia, treatments given very early in the pregnancy, probably at about the time of conception. This case went to full term with a normal child. One case of pubic eczema, treated over six areas, six being given apparently about the time of conception; the case went to full term, with normal child. One case with treatment of fibroid, treatments given during the second and third months of pregnancy, full term delivery, normal child. One case of metrorrhagia, treatments given during the first and second months, full term, normal child. One case of carcinoma of the cervix, treated by radium, apparently during the fifth and sixth months, premature labor, normal child. One case of metrorrhagia treated by roentgen rays before pregnancy occurred, apparently a normal pregnancy, incomplete at final report. One case treated for patient's desire to produce sterility about the

time conception took place, full term pregnancy, normal twins. One case of fibroid treated at three months, delivered at term, stillborn child. One case of fibroid treated during the second month, full term, normal child. Postoperative treatment for carcinoma of breast, during the third month, patient went on to full term with normal child. One case of fibroid, treated during the third month of pregnancy, normal child at full term. One case of pubic eczema treated during the third month, normal child at full term. One case of pruritus vulvae, treatment during the fourth and fifth months, normal child at full term. These have been tabulated so that of the 13 cases, 10 went to full term with normal children, including one pair of twins; one premature labor, normal child; one case of incomplete pregnancy at time of report; one case was stillborn at term. Of this group of cases, there was only one case of stillbirth.

Form C. Form C of this questionnaire was framed to elicit information regarding the effect of occupational irradiation on sex life. There were 381 replies, of which 4 were so indefinite that it was deemed best to exclude them. Accordingly, in this report there are data upon 377 roentgenologists. The average age when these individuals began the practice of roentgenology was 30.6 years. The average age of individuals included in this report was 43.7 years. The average number of years reported upon, therefore, is 13.1 years.

The number who have had children during the time that they were practicing roentgenology was 205. The average number of years in roentgenology before the last child was born was 7.88 years. These roentgenologists reported a total of 657 children, of which 262 were born before taking up roentgenology. There were 395 children born after the individuals began work in roentgenology. A further survey showed that in the age period of the father from twenty to twenty-nine years, there were 63 children born. During the period between the ages of thirty and thirty-nine years, there were 245½ children born. In the period from forty to forty-nine years, there were 83 children born. Four children were born after the paternal age of fifty. Of the number of radiologists to whom no children were born during the period of work in roentgenology, there was 172. From this should be deducted 16 who were single, and a further number of 12 who gave explicit causes, other than radiation, for their sterility. A further number of 6 should be deducted who stated that contraceptives had been employed during the entire period of work. The number, therefore, of radiologists who reported themselves as childless was 138, or a percentage of 36.6. Of this number, 93 were under the age of forty, and 45 were over the age of forty when roentgen-ray work began.

In the families reported of radiologists having children, the average number of children was 2.2. It was difficult to find statistics which would give a definite comparison of the average number of children of physicians not engaged in roentgenology, but in one set of statistics, it was stated that physicians between the ages of forty and forty-four had an average number of 3 children. From this same table of statistics, it was found that the approximate average number of children born to physicians or surgeons between the ages of forty and forty-four was 3. The average number of children born to the group of radiologists sending in reports to this questionnaire (of the average age of 43.7 years), was 1.74. From this it will be seen that the birth rate in families of radiologists is slightly lower than that in physicians as a group.

Out of these 377 reports, there is one group of 19 who stated definitely that there was microscopic evidence of sterility. Of this special group of 19, the average age when work in roentgenology began was twenty-nine years and the average number of years during which the profession of radiology was followed was 19.3 years. The average length of time of this group in which radium therapy was practiced was 10.9 years. Of these 19 showing evidence of sterility, there was one who made use of radium alone. Of this group, the average number of hours reported as occupied each day in roentgen-ray and radium work was 1.9 hours. There

was a second group of 7 who stated that they were periodically sterile, basing their statement upon microscopical proof. Of this small group, the average age when individuals began radiology was thirty years. The average number of years during which this special line of work was followed was 13.4 years. Of the group of 7 stating partial sterility, the average number of years per day devoted to roentgen-ray and radium work was eight.

The report as to the number of abortions and premature labors was as follows. Of this entire group, 7 reported premature labors and abortions before beginning roentgen-ray work and 17 during the period of roentgen-ray activity. Of the children born before roentgen-ray work was undertaken, there were 262; during the time of radiation employment, 395. The number of conceptions occurring in the group before roentgen-ray work commenced was 269; during roentgen-ray work, 412. The percentage of abortions and premature labors before roentgen-ray work was 4.13. Totalling groups one and two, where there was microscopic proof of either partial or complete sterility, the number was 26. Of these, 2 were occupied with radium alone. The average number of years in which this occupation was followed was 17.7, and the average number of hours per day was 5.3.

Of the group of 19 who stated that they were completely sterile, there was no evidence for 6 of them that they had not been sterile before roentgen-ray work was begun. Of this group of 19, five had had children born before roentgen-ray work was started and 3 had the microscopic proof of activity of gonads before roentgen-ray work was started. Of the group of 7 stated to be partially sterile, one had no proof that he had not been previously sterile.

The answers to the question as to change in libido showed that 311, or 82.5 per cent reported no evidence of change; 27 or 7.2 per cent reported increase in libido; 30, or 7.9 per cent reported decreased libido. Question was unanswered in 2.4 per cent.

In reply to the question as to the periodicity of libido, 26, or 6.9 per cent reported that such periodicity was present; 330, or 87.5 per cent, reported no periodicity of libido. Question was unanswered in 21 cases, or 5.6 per cent. Of the first and second groups reporting complete or partial sterility, 26 cases in all, 22 reported libido unchanged; 3 reported libido increased; and 1 reported libido decreased.

The following answers were given to the questions concerning potency. In groups one and two, a total of 26 cases of complete and partial sterility, potency was not affected in 23, possibly affected in one, partially lost in one, and periodically lost in one. Out of the general group of 377, potency was reported as unaffected in 314; partially lost in 22; completely in 2; periodically in 12; and the question was unanswered in 27.

In respect to the question of abnormal children, it was noted that 3 children, definitely stated to be abnormal, were born before the father commenced work in roentgenology. Of these abnormal children, two were Mongolian idiots. After roentgen-ray work was commenced, there were 7 abnormal children reported. However, a close survey of these includes some with minor defects, as 2 cases of strabismus, one of enlarged thymus, one of brain tumor, and one of astigmatism. It is an open question if these changes could be charged to roentgen-ray exposure. It is noteworthy that out of these 7 cases of abnormal children, there was only one Mongolian idiot. Consequently, it is worthy of remark that 2 cases of Mongolian idiocy were reported as born before roentgen-ray work was commenced, and only one born after this work was commenced. In this questionnaire, 14, or 3.71 per cent, volunteered the statement that they had suffered from roentgen-ray dermatitis. The average number of years of work of those giving this report of roentgen dermatitis was 20.13 years. It is also interesting to note that none of these dermatitis cases were among those showing partial or complete sterility.

The number of those who gave figures as to their daily work was 248, and the average number of hours of those reported

was 4.12. The total number of reports was 377. Of these, 227 followed roentgen rays alone, 8 employed radium alone, and 142 combined roentgen rays and radium. The longest use of roentgen rays as a specialty was thirty years, and for radium twenty-two years.

The reports on protection employed were so indefinite that their tabulation would be of little value.

It is to be hoped that a like questionnaire, with questions more precise and perhaps more elaborate, will be sent out again after four or five years. This future questionnaire should include questions as to the children of the second generation.

Vol. XVIII, No. 5

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

Editor: ARTHUR C. CHRISTIE, M.D.

Editorial Board: JAMES T. CASE, M.D. H. K. PANCOAST, M.D. WILLIAM DUANE, PH.D.

Advisory Board for Pathology: JAMES EWING, M.D. EUGENE OPIE, M.D. A. S. WARTHIN, M.D.

Collaborating Editors: The Officers and Committee Members of the Societies of which this JOURNAL is the official organ, whose names appear on this page, are considered collaborating editors of this JOURNAL.

Foreign Collaborators: A. BÉCLÈRE, M.D., PARIS. GÖSTA FORSSELL, M.D., STOCKHOLM. G. F. HAENISCH, M.D., HAMBURG. ROBERT KNOX, M.D., LONDON. R. LEDOUX-LEBARD, M.D., PARIS.

Publishers: PAUL B. HOEBER, INC., NEW YORK

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application. Editorial office, 1909 Massachusetts Ave., N. W., Washington, D.C. Office of publication, 76 Fifth Avenue, New York.

Information of interest to all readers will be found on page ii.

Officers and Standing Committees

THE AMERICAN ROENTGEN RAY SOCIETY

President: A. HOWARD PIRIE, Montreal, Canada; *President-Elect:* E. H. SKINNER, Kansas City, Mo.; *1st Vice-President:* R. D. LEONARD, Boston, Mass.; *2d Vice-President:* LAWRENCE REYNOLDS, Detroit, Mich.; *Secretary:* JOHN T. MURPHY, 421 Michigan Ave., Toledo, Ohio; *Treasurer:* WILLIAM A. EVANS, 10 Peterboro St., Detroit, Mich.; *Librarian and Historian:* H. W. DACHTLER, Toledo, Ohio.

Executive Council: WILLIAM DOUGHTY, Chairman, 628 Elm St., Cincinnati, Ohio, G. W. GRIER, Pittsburgh, Pa., W. F. MANGES, Philadelphia, A. H. PIRIE, Montreal, Canada, E. H. SKINNER, Kansas City, Mo., A. C. CHRISTIE, Washington, D. C., JOHN T. MURPHY, Toledo, Ohio, WILLIAM A. EVANS, Detroit, Mich.

Committee on Laws and Public Policy: B. R. KIRKLIN, Chairman, Rochester, Minn., FRED M. HODGES, Richmond, Va., WILLIAM E. CHAMBERLAIN, San Francisco, Calif.

Safety Committee: P. M. HICKEY, Chairman, University Hospital, Ann Arbor, Mich., H. K. PANCOAST, Philadelphia, Penna., W. D. COOLIDGE, Schenectady, N. Y., A. U. DESJARDINS, Rochester, Minn., H. J. ULLMANN, Santa Barbara, Calif., B. H. NICHOLS, Cleveland, O., G. E. RICHARDS, Toronto, Can., R. R. NEWELL, San Francisco, Calif.

Committee on Scientific Exhibit: LAWRENCE REYNOLDS, Chairman, 10 Peterboro St., Detroit, Mich., J. E. PANNETON, Montreal, Canada, W. A. WILKINS, Montreal, Canada.

Publication Committee: WILLIAM A. EVANS, Chairman, Detroit, Mich., G. W. GRIER, Pittsburgh, Pa., W. F. MANGES, Philadelphia.

Member, National Research Council: H. K. PANCOAST, Philadelphia, Pa.

Editor: A. C. CHRISTIE, 1909 Massachusetts Ave., N. W., Washington, D. C.

Editorial Board: JAMES T. CASE, H. K. PANCOAST, WM. DUANE.

Advisory Board for Patbology: JAMES EWING, EUGENE OPIE, ALDRED S. WARTHIN.

Publishers: PAUL B. HOEBER, Inc., 76 Fifth Avenue, New York City.

Twenty-ninth Annual Meeting: Kansas City, Mo., 1928. Date to be announced.

THE AMERICAN RADIUM SOCIETY

President: CURTIS F. BURNAM, 1418 Eutaw Place, Baltimore, Md.; *President-Elect:* EDWIN C. ERNST, St. Louis, M.; *First Vice-President:* BURTON, J. LEE, New York City; *Second Vice-President:* H. H BOWING, Rochester, Minn.; *Secretary:* G. W. GRIER, Jenkins Arcade, Pittsburgh, Penna.; *Treasurer:* ZOE ALLISON JOHNSTON, Pittsburgh, Penna.

Executive Committee: WM. S. NEWCOMET, Chairman, Philadelphia; DOUGLAS QUICK, New York City; ALBERT SOILAND, Los Angeles, Calif.

Program Committee: EDWIN C. ERNST, Chairman, St. Louis, Mo.; JAMES A. CORSCADEN, New York City; W. H. CAMERON, New York City.

Publication Committee: HENRY K. PANCOAST, Chairman, Philadelphia; JAMES T. CASE, Battle Creek, Mich.; B. F. SCHREINER, Buffalo, N. Y.

Standardization Committee: G. FAILLA, Chairman, New York City; HENRY J. ULLMANN, Santa Barbara, Calif.; ROBERT B. GREENOUGH, Boston.

Committee on Arrangements: H. H. BOWING, Chairman, Rochester, Minn.; A. S. FLEMING, Minneapolis, Minn.; LEDA J. STACY, Rochester, Minn.

EDITORIALS

WHO SHALL PRACTICE MEDICINE?

SURGERY, Gynecology and Obstetrics for November, 1927, contains an editorial entitled, "Nurse versus Doctor." It deals with certain conditions in hospitals in which it appears that nurses are assuming duties which properly belong only to the physician. The subject is introduced as follows: "The standing of the medical profession has been won by many years of strenuous endeavor. The actuality and scientific basis of our achievements distinguish us from the various cults; and our knowledge and experience place us upon a higher level than the trained nurse, however admirable in her own field a nurse may be.

"It goes without saying that this hard-won prestige should be guarded with jealous care, not only for ourselves but for those who are to follow us."

It is safe to say that there are few physicians who would take any exception to the above statement, and yet an abuse has arisen in the profession which is much more prevalent and much more potential for harm both to the medical profession and to the laity than any probable usurpation of medical authority by trained nurses. This abuse consists in the actual diagnosis and treatment of disease by radiological technicians. It is a matter of common knowledge that this is a widespread practice and that trained nurses are by no means the principal offenders. In fact, it is a rather general observation that commercial roentgen-ray laboratories are usually operated by male technicians and that the male technician in office or hospital is much more likely to assume the physician's rôle than are trained nurses with their background of training in medical ethics and close contact with the medical profession.*

It is well known that there is a widespread and probably growing tendency to depend upon lay technicians, not only for the technical work which is their proper field, but for opinions on the roentgen findings, and even for diagnosis of the underlying pathological process. The medical profession itself is largely to blame for the development of this abuse just as it has been responsible by neglect of certain fields for the success of most of the medical cults. Roentgenologists themselves must bear at least a part of the blame for the assumption of medical functions by the technician. It is true that many roentgenologists take a very serious view of their responsibilities as medical consultants and follow the general practice of seeing every patient referred to them for roentgen-ray diagnosis, and their final opinion is based not only upon the roentgen-ray findings but upon a knowledge of the history of the case and all other other information available. But on the other hand, there are many who base their entire report upon the roentgen findings alone, perhaps even upon films alone, never having seen the patient and having no knowledge whatever of the previous history, the course of the disease, nor the patient's present condition. There are, of course, situations in which the above course is not censurable, where the final results are to be evaluated by a well-trained internist who is capable of giving all information its due weight. Even in such instances, however, it is probable that better results are achieved by close co-operation and consultation between the internist and the roentgenologist than can be obtained by the roentgenologist's submitting a report based upon roentgenologic examination alone. It is a fact that in many offices and hospitals the only person who really sees the patient who is referred for roentgen examination is the roentgen technician, and in many

* See Editorial on this subject, AM. J. ROENTGENOL. & RAD. THERAPY, 1926, xvi, 257.

such places the technician's opinion is the only one sought. It is therefore not to be wondered at that the general physician who refers patients to roentgenologists for examination gradually comes to depend upon the technician for his findings rather than upon the doctor and that he finally adopts the practice of sending his patients to a commercial roentgen-ray laboratory or depends upon the report of a lay technician in a hospital. Only a little reflection, however, will show that such practice is not in line with general medical progress and that it carries actual and potential dangers of great importance. At the present time all over this country the roentgen ray is being used for diagnosis and treatment of disease not only by variously trained lay technicians but by the practitioners of almost all of the medical cults whether or not they are licensed to practice medicine. In recent times it is reported that even "beauty parlors" have used the roentgen ray extensively for the removal of superfluous hair.*

The cure for the "technician evil" lies entirely within the medical profession. It will undoubtedly persist so long as there are a considerable number of physicians who do not realize that there is a wide gap between the films produced by the technician and their translation into terms of underlying pathology. The cure of the evil will be in sight when physicians realize that they are fostering another class of irregular, ignorant, unlicensed medical practitioners who are already rendering reports of roentgen-ray findings directly to patients and in some instances even using the roentgen ray as a therapeutic agent. In the meantime, the roentgenologist who takes a high view of his obligations would do well to review his own attitude and practice in the employment of technicians.

DR. CASE HONORED BY LATIN AMERICANS

At the recent annual meeting of the American Roentgen Ray Society held in Montreal, Dr. Pedro Farinas of Havana, representing fifteen Latin American countries, presented to Dr. James T. Case of Battle Creek, Michigan, a testimonial as an expression of appreciation for his important contributions to the progress of radiology in Latin America. The testimonial bore the Spanish designation "Pergamino" meaning a parchment and referring originally to illuminated parchments such as diplomas, certificates of appreciation, etc. The Pergamino presented to Dr. Case contained the fifteen testimonials beautifully mounted in one large frame. Each of the testimonials bore its respective national flag and was signed by the members of the national radiological society. At the bottom of the frame is an engraved plate with the following legend: "Testimonial to Dr. Case as an Expression of Appreciation for His Important Contributions to the Progress of Radiology in Latin America." The following countries are represented in the testimonial: Guatemala, Cuba, Colombia, Ecuador, Nicaragua, Salvador, Argentina, Mexico, Chile, Paraguay, Uruguay, Peru, Porto Rico, Brazil, Venezuela.

Dr. Case has for many years been in close contact with our radiological colleagues in Cuba, Porto Rico, Mexico and the countries of South America. His "Stereostopic Atlas on the X-ray Examination of the Alimentary Tract" was published in Spanish nearly ten years ago, having been translated by Dr. Gonzalez Martinez of Porto Rico. It has had a wide circulation in South America. In 1923 Dr. Case made a trip to South America in conjunction with a group of surgeons from the American College of Surgeons, at which time he renewed many of the acquaintances which he had already made in Paris or in this country. In the winter of 1924–1925 he went to Lima, Peru, as a delegate from the Surgeon General of the Army and from Northwestern University to the Third Pan American Scientific Congress which was held in Lima following the celebration of the Battle of Ayacucho which represented the hundredth anniversary of the freedom of Latin America from Spain. After nearly a month spent in Lima in connection with the Congress, he made a trip around South America giving lectures before the medical schools of each of the principal universities (Lima, Santiago, Valparaiso, Buenos Aires,

* Editorial, Am. J. Roentgenol. & Rad. Therapy, 1925, xiv, 345.

Montevideo, and Sao Paulo and Rio de Janeiro). This year he was the guest of the Mexican government for three weeks while giving a series of twelve lectures before the National Medical School of Mexico City and the medical schools in Pueblo and Guadalajara. A little later Dr. Case went to Havana as the guest of the University of Havana, School of Medicine, and there he gave another series of lectures on radiological subjects. Dr. Case has been honored by membership in the Academy of Medicine of Peru, Brazil, Porto Rico and Cuba and has been made a member of the radiological societies of various countries and a member of the surgical society of Peru.

The radiologists of the United States feel greatly gratified at this token of the appreciation in which Dr. Case is held by our Latin American colleagues. We congratulate him upon the honor thus bestowed and feel that it will serve to bring radiologists of Pan America into closer and more cordial relationships.

AUGUSTUS ROBERT TAFT

It is with great regret that we announce the death of Dr. Augustus Robert Taft of Charleston, S. C. Dr. Taft, who was fifty-four years of age, died suddenly on September 20, 1927, in an attack of angina, never having had a previous attack. Dr. Taft graduated from the Medical College of the State of South Carolina in 1895. He served during the World War, and at the time of his death he held the chair of professor of physical therapy and roentgenology at his alma mater. Besides the American Roentgen Ray Society he was also a member of the Radiological Society of North America and of the American Radium Society. The Society has lost a very charming man, an able roentgenologist and a leader in the medical profession of South Carolina.

Subscribers to THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY *visiting New York City, are invited to make the office of* THE JOURNAL *(76 Fifth Avenue, New York) their headquarters. Mail, packages or bundles may be addressed in our care. Hotel reservations will gladly be made for those advising us in advance; kindly notify us in detail as to requirements and prices. List of operations in New York hospitals on file in our office daily.*

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this column solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. John T. Murphy, 421 Michigan Ave., Toledo, Ohio.
Twenty-ninth annual meeting, Kansas City, Mo., 1928. Date to be announced.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. Fred M. Hodges, 801 West Grace St., Richmond, Va.
Annual meeting, Minneapolis, Minn., June 11–15, 1928.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. Robert J. May, St. Luke's Hospital, Cleveland, Ohio.
Annual meeting, New Orleans, La., Nov. 28–Dec. 2, 1927.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. E. C. Samuel, New Orleans, La.
Annual meeting, Memphis, Tenn., Nov. 14–17, 1927.

BUFFALO RADIOLOGICAL SOCIETY
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St.
Meets second Monday of each month except during the summer months, the place of meeting to be selected by the host.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. R. A. Arens, Michael Reese Hospital
Meets monthly on second Thursday from October to May (except during month of December) at Virginia Hotel. Dinner at 6 P.M., scientific session at 8 P.M.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. James H. West, 8314 Euclid Ave.
Meetings are held at 6 o'clock at the University Club, on the fourth Monday evening of each month from September to April, inclusive.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. Henry L. Ulbrich, 1130 E. Grand Blvd.
Meets monthly on second Friday from October to May, at Wayne County Medical Society Building.

CENTRAL ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. H. C. Kariher, Decatur, Illinois.
Regular meetings held quarterly.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. M. C. Sosman, Peter Bent Brigham Hospital, Boston, Mass.
Meets monthly on third Friday, Boston Medical Library.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. E. Everett Rowell, 8 West 16th St.
Meets monthly on third Monday, New York Academy of Medicine.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. D. S. Childs, 316 Gurney Bldg., Syracuse, N. Y. Three meetings a year—April, August and November.

PACIFIC COAST ROENTGEN RAY SOCIETY
Secretary, Dr. Harold B. Thompson, Seattle, Wash.
Two meetings a year.

ROENTGEN RAY SOCIETY OF CENTRAL PENNSYLVANIA
Secretary, Dr. W. E. Reiley, Clearfield, Penna.
Two meetings a year, April and October.

PHILADELPHIA ROENTGEN RAY SOCIETY
Secretary, Dr. Eugene Pendergrass, University of Pennsylvania, Philadelphia.
Meets monthly on first Thursday evening, Pennsylvania Hospital.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. James M. Flynn, 282 Alexander St.
Meets monthly on the first Friday evening at 7.45 at the Rochester Medical Association Building.

ST. LOUIS ROENTGEN CLUB
Secretary-Treasurer, Dr. L. R. Sante, Metropolitan Building.
Meets first week of each month. Time and place of meetings designated by president.

TEXAS RADIOLOGICAL SOCIETY
Secretary-Treasurer, Dr. C. P. Harris, Houston, Texas.
Annual meeting, Galveston, Texas, 1928.

British Empire

BRITISH RÖNTGEN SOCIETY
Meets on the first Tuesday of each month from November to June inclusive, at 8.15 P.M., at the British Institute of Radiology, 32 Welbeck St., London; W. 1.

BRITISH INSTITUTE OF RADIOLOGY
Secretary, Dr. John Muir, 32 Welbeck St., London, W. 1.
Meets at 32 Welbeck St., but regular dates and times of meeting have not yet been arranged.

ELECTRO-THERAPEUTIC SECTION OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)
Meets on the third Friday of each month during the winter at 8.30 P.M. at the Royal Society of Medicine, 1 Wimpole St., London, W. 1.

RADIOLOGICAL SECTION, AUSTRALASIAN MEDICAL CONGRESS
Secretary, Dr. C. A. Anderson, The Hospital, Dunedin.

RADIOLOGICAL SECTION OF THE VICTORIAN BRANCH OF THE BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Colin Macdonald, Lister House, 61 Collins St., Melbourne, Australia.
Meets monthly at Melbourne during the winter.

CANADIAN RADIOLOGICAL SOCIETY
Secretary, Dr. E. C. Brooks, Montreal.

RADIOLOGICAL SECTION, NEW ZEALAND BRITISH MEDICAL ASSOCIATION
Secretary, Dr. P. C. Fenwick, The Hospital, Christchurch.
Meets annually.

* Secretaries of societies not here listed are requested to send the necessary information to the editor.

CONTINENTAL EUROPE

BELGIAN SOCIETY OF ROENTGENOLOGY
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

ASSOCIATION OF GERMAN ROENTGENOLOGISTS AND RADIOLOGISTS IN CZECHOSLOVAKIA
Secretary, Dr. Walter Altschul, German University, Prague, 11/52.

DEUTSCHE RÖNTGEN-GESELLSCHAFT (GESELLSCHAFT FÜR RÖNTGENKUNDE UND STRAHLENFORSCHUNG)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.
Next meeting with the Gesellschaft deutscher Naturforscher und Aerzte will be in Hamburg, September, 1928.

SUD- UND WESTDEUTSCHE RÖNTGENGESELLSCHAFT
Meets annually in different cities.

NORD- UND OSTDEUTSCHE RÖNTGENGESELLSCHAFT
Meets annually in different cities.
Next meeting September 27, 1928, in Hamburg.

DUTCH SOCIETY OF ELECTROLOGY AND ROENTGENOLOGY
Holds two meetings a year in Amsterdam, one in the Spring, and one in the Fall.

SOCIETA ITALIANA RADIOLOGIA MEDICA
Secretary, Professor M. Ponzio, University of Turin, Turin.

ALL-RUSSIAN ROENTGEN RAY ASSOCIATION, LENINGRAD, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs S. A. Reinberg and S. G. Simonson.
Meets annually.
Fifth Annual Meeting in Kiev, Ukraine, May, 1928.

LENINGRAD ROENTGEN RAY SOCIETY
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly on the first Monday at 8 o'clock in the State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

SCANDINAVIAN ROENTGEN SOCIETIES
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with the exception of the Denmark Society, meets every second month except in the summertime:

SOCIETY OF MEDICAL RADIOLOGY OF SWEDEN
Meets in Stockholm.

SOCIETY OF MEDICAL RADIOLOGY IN NORWAY
Meets in Oslo.

SOCIETY OF MEDICAL RADIOLOGY IN DENMARK
Secretary, Dr. H. Scheuermann, Copenhagen
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

SOCIETY OF MEDICAL RADIOLOGY IN FINLAND
Meets in Helsingfors.

VIENNA SOCIETY OF ROENTGENOLOGY
Secretary, Professor Holzknecht, Vienna, IX, General Hospital.
Meets on the first Tuesday of each month from October to July.

SECOND INTERNATIONAL CONGRESS OF RADIOLOGY REVISED ITINERARIES

Upon the advice of the representative of the Swedish State Railways, Thos. Cook and Son have made slight revisions of the itineraries published in the October number of the Journal. It will be noted by examining the itineraries published below that practically the only changes are made in the Swedish and Norwegian portions of the tour:

TOUR NO. 5

May 30th	Sail from New York by Cunard Line Cabin Steamer "Lancastria."
June 8th	Arrive Havre and rail to Paris.
June 9th to June 20th	*In Paris.* Private automobile bus and guide will be at passengers' disposal for two days' sightseeing as follows: 1st Day: Visiting the city, including the Louvre, Cathedral of Notre Dame, Eiffel Tower, Napoleon's Tomb, Tomb of the Unknown Soldier, etc. 2nd Day: To Versailles and the Chateau of Malmaison.
June 21st	Day train via Metz to Frankfort.
June 22nd to June 26th	*In Frankfort.* Private automobile and guide will be at passengers' disposal for one day's sightseeing about the city.
June 27th	Rail to Nuremberg.
June 28th	To Vienna.
June 29th to July 3rd	*In Vienna.* Private automobile bus and guide will be provided for one day's drive around the city, visiting the many points of interest.
July 4th	Rail to Prague.
July 5th	To Berlin.
July 6th to July 10th	*In Berlin.* Private automobile bus and guide provided for half day's drive in the city and one day to Potsdam and return.
July 11th	To Hamburg on morning train.
July 12th to July 16th	*In Hamburg.* Private automobile and guide will be at passengers' disposal for one day's sightseeing around the city. Night train to Copenhagen. (Sleeping car berth included.)
July 17th	*At Copenhagen.* Private automobile and guide will be at passengers' disposal for full day's sightseeing about the city.
July 18th	Rail to Gothenburg.
July 19th	*At Gothenburg.* Private automobile and guide will be at passengers' disposal for full day's sightseeing about the city.
July 20th	Leave by steamer via Gota Canal for Stockholm.
July 21st	En route on Canal Steamer.
July 22nd	Arrive Stockholm.
July 22nd to July 28th	*At Stockholm.* No hotel accommodations or sightseeing provided by Thos. Cook & Son.

July 20th Rail to Rattvik.
July 30th and July 31st *At Rattvik.* Private automobile provided for excursions around Lake Siljam.
Aug. 1st Rail to Oslo.
Aug. 2nd *At Oslo.* Private automobile and guide will be at passengers' disposal for full day's sightseeing about the city.
Aug. 3rd Rail to Bergen.
Aug. 4th Embark on B. & N. Steamer for Newcastle.
Aug. 5th Arrive Newcastle P.M. and rail to London.
Aug. 6th to Aug. 10th *At London.* Private automobile and guide will be at passengers' disposal for two days' visiting points of interest as follows:
1st Day: In the city, visiting London Museum, Tower of London, St. Paul's Cathedral, Guildhall, Mansion House, Buckingham Palace, etc.
2nd Day: To Windsor, Eton College and Stoke Poges, etc.
Aug. 11th Rail to Southampton and sail for New York by Cunard Line Steamer.

TOUR NO. 6

July 5th Sail from New York by Swedish American Line steamer "Gripsholm."
July 14th Arrive Gothenburg.
July 15th *At Gothenburg.* Private automobile and guide will be at passengers' disposal for full day's sightseeing about the city.
July 16th Rail to Oslo.
July 17th and July 18th *At Oslo.* Private automobile and guide will be at passengers' disposal for one day's sightseeing about the city.
July 19th Rail to Rattvik.
July 20th and July 21st *At Rattvik.* Private automobile for excursions around the Lake Saljam.
July 22nd Rail to Stockholm.
July 22nd to July 27th *At Stockholm.* No hotel accommodation or sightseeing provided here by Thos. Cook & Son.
July 28th Leave in the evening by steamer for Visby.
July 29th *In Visby.* Visit city Wall and Church Ruins. Excursion by motor to Snackgardet Beach. Leave on evening steamer through Kalmar Sound.
July 30th Arrive at Kalmar early A.M. Visit the Medieval Castle and Old City. Leave on afternoon train for Copenhagen.
July 31st *In Copenhagen.* Private automobile bus and guide provided for full day's sightseeing about the city.
Aug. 1st Day train to Hamburg.
Aug. 2nd to Aug. 5th *In Hamburg.* Private automobile and guide provided for one day's sightseeing around the city.
Aug. 6th Morning train to Berlin.
Aug. 7th to Aug. 11th *In Berlin.* Private automobile bus and guide provided for half day's drive in the city, also one day to Potsdam and return.
Aug. 12th Rail to Prague.
Aug. 13th To Vienna.
Aug. 14th to Aug. 18th *In Vienna.* Private automobile bus and guide will be at the passengers' disposal for one day's sightseeing to points of interest about the city.
Aug. 19th Rail to Nuremberg.
Aug. 20th To Frankfort.
Aug. 21st to Aug. 25th *In Frankfort.* Private automobile and guide will be at passengers' disposal for one day's sightseeing about the city.
Aug. 26th Day express via Metz to Paris.
Aug. 27th to Sept. 7th *In Paris.* Private automobile and guide will be at the passengers' disposal for two days' sightseeing as follows:
1st Day: In the city, visiting the Louvre, Cathedral of Notre Dame, Eiffel Tower, Napoleon's Tomb, Tomb of the Unknown Soldier, etc.
2nd Day: To Versailles and the Chateau of Malmaison.
Sept. 8th Via Calais and Dover to London.
Sept. 9th to Sept. 15th *In London.* Private automobile bus and guide will be at the passengers' disposal for two days' sightseeing as follows:
1st Day: In the city visiting London Museum, Tower of London, St. Paul's Cathedral, Buckingham Palace, etc.
2nd Day: To Windsor Castle, Eton College, Stoke Poges.
Sept. 16th Rail to Southampton and sail for New York by Cunard Line Cabin Steamer.

TOUR NO. 7

July 5th Sail from New York by Swedish American Line Steamer, "Gripsholm."
July 14th Arrive Gothenburg.
July 15th *At Gothenburg.* Private automobile and guide will be at passengers' disposal for full day's sightseeing about the city.
July 16th Rail to Oslo.
July 17th and July 18th *At Oslo.* Private automobile and guide at passengers' disposal for one day's sightseeing about the city.
July 19th Rail to Rattvik.
July 20th and July 21st *At Rattvik.* Private automobile for excursions around Lake Siljam.
July 22nd Rail to Stockholm.
July 22nd to July 27th *At Stockholm.* No hotel accommodations or sightseeing provided here by Thos. Cook & Son.
July 27th Leave on night train for Gothenburg. (Sleeping car berth included.)
July 28th Arrive Gothenburg and embark on S. S. "Gripsholm" for New York.

TOUR NO. 8

July 7th Sail from New York per S. S. "Republic" of the United States Line.
July 19th Arrive Bremen.
July 20th Leave on morning train via Malmo for Stockholm. (Sleeping car berth included.)
July 21st Arrive Stockholm A.M.
July 21st to July 27th *At Stockholm.* No hotel accommodations or sightseeing provided here by Thos. Cook. & Son.
July 27th Leave on night train for Gothenburg. (Sleeping car berth included.)
July 28th Arrive Gothenburg and sail for New York per S. S. "Gripsholm."

NEW ENGLAND ROENTGEN RAY SOCIETY

At the annual meeting of the New England Roentgen Ray Society the following officers were elected for the ensuing year: President: Dr. Curtis H. Jennings, Fitchburg, Mass.; Vice-President: Dr. Frank W. Lamb, Portland, Me.; Secretary-Treasurer: Dr. Merrill C. Sosman, Boston, Mass.;

Member Executive Committee: Dr. A. S. Merrill, Manchester, N. H.

Eight meetings were held during the year and thirteen new members were admitted, bringing the total to 116. Five men were proposed and elected as honorary members of the society in recognition of their early and important work in roentgenology. They are: Dr. Walter Cannon, professor of physiology, Harvard Medical School, Boston, Mass.; Dr. Ernest A. Codman, surgeon, Boston, Mass.; Mr. Joseph Godsoe, former assistant of Dr. Walter Dodd at the Massachusetts General Hospital, Boston; Prof. Elihu Thomson of the General Electric Company, Lynn, Mass., and Dr. Francis H. Williams, physician, Boston.

M. C. Sosman,
Secretary-Treasurer.

BOOK REVIEWS

Books Received Are Acknowledged under Heading: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

X-Rays and Electrons: An Outline of Recent X-Ray Theory. By Arthur H. Compton, Ph.D. Professor of Physics in the University of Chicago. Cloth. Pp. 403, with 132 illustrations. New York: D. Van Nostrand Co., 1926.

The student of the subject recognizes that our knowledge of atomic structure and of radiation has been advanced more by x-ray studies than by any other single field of investigation in recent years. X-ray studies have enabled us to count the number of electrons in the various atoms and have informed us regarding their distribution and the forces that hold them in position. This is in part because of the very short wave length of roentgen rays. The theoretical limit of the microscope, using ordinary light, does not permit us to determine the shape of a body much smaller than a wave length of light, 0.0005 mm. If an x-ray microscope could be employed this limit might be reduced by a factor of 10,000 and we should then be working in the region of subatomic dimensions. Though such an instrument does not exist, interference effects due to x-rays traversing groups of atoms can be measured, and from them we are able to interpret the structure of the matter giving rise to a particular diffraction pattern almost as definitely as if an x-ray microscope were employed.

Similarly in the field of radiation, it is the high frequency which gives significance to experiments with roentgen rays. Since the magnitude of the energy quantum is proportional to the frequency, quantum phenomena such as the photoelectric effect, which can be studied only statistically when visible light is used, can with x-rays be considered as individual events. That is to say, the effects of individual x-ray quanta can be observed and measured. This is where x-ray investigations have supplied us with the best determinations of Planck's fundamental constant *h*. It is also the comparatively large energy and momentum associated with the quantum of x-rays which have made possible the recent experiments on the change of wave length of scattered x-rays and allied effects, pointing so definitely to a quantum structure of radiation itself.

These prefatory remarks by Professor Compton indicate the general background of the treatise under review. The book attempts to cover the whole field of the physics of roentgen rays with some completeness, but those aspects most closely allied with the author's own researches are treated in greater detail. Only an introduction to the problems of crystal structure and x-ray spectroscopy is given. The author has been concerned chiefly with the information roentgen-ray studies have afforded regarding the structure of the atom and the nature of the rays themselves; and the present work deals chiefly with the interpretation of the properties of roentgen rays in terms of the interaction between radiation and electrons. The first half of the book treats the subject from the standpoint that the study of roentgen rays is a branch of optics. It is shown that classical electromagnetic theory is unable to account satisfactorily for the scattering of very short roentgen rays. This is the point where the laws of interference and diffraction which have been found flawless in ordinary optics are found to fail when roentgen rays and gamma rays are concerned. Further in the book there is demonstrated that as regards intensities as well as wave lengths the quantum theory of scattering finds itself established on a firm experimental basis.

Many parts of the subject are dealt with from a mathematical standpoint in order to give a correct impression of the methods and reasoning employed in solving the problems; it is pointed out that it is by these mathematical processes that the most important results are often first obtained, and it would be unfair to give the impression that they can be secured in any other way. An idea of the contents of the volume may be obtained from the chapter headings: 1. The discovery and properties of x-rays. 2. X-rays and electrodynamics. The electromagnetic theory of the production of x-rays. 3. The scattering of x-rays. 4. X-ray reflection and crystal structure. 5. Intensity of the reflection of x-rays from crystals. 6. The absorption of x-rays. 7. The refraction of x-rays. 8. X-rays and quantum theory. The photoelectric effect with x-rays. 9. Quantum theory of x-ray scattering. 10. Quantum theory of x-ray diffraction. 11. X-ray spectra. 12. Quantum theory of x-ray production and absorption. A series of appendices giving certain mathematical derivations and tables completes the book.

It might be urged that it is not essential nor practicable for the commuter traveling

daily across the Brooklyn Bridge to know all details regarding the strength of steel, stone, cement, foundation work, beams, struts and braces, and safe loads any more than for the practicing medical roentgenologist to be fully conversant with the fundamental mathematical aspects of radiation and the structure of matter. Life is short, and the mathematical treatment necessarily demanded in this volume will prove a deterrent to the hopeful tyro who ventures to glance within its covers. Yet when one reflects that in the field of roentgen and radium therapy which is at present maze of dubious experimentation and conflicting empiricism, one is dealing with precisely the same fundamental problem, namely, the interaction of radiations and matter, one feels intuitively that this contribution of Professor Compton's and similar ones by Kaye, de Broglie and others have an important bearing on the problem. An elucidation of the elementary aspects such as is contributed by Professor Compton provides the bed-rock upon which scientific progress may be firmly founded; it is noteworthy that radiologists are constantly utilizing these developments to build a sound and useful edifice of theory and practice.

B. Cohen.

BOOKS RECEIVED

Urography. By William F. Braasch, B.S., M.D., F.A.C.S., Head of Section of Urology, Mayo Clinic; Professor of Urology, Mayo Foundation for Medical Education and Research, Graduate School, University of Minnesota, in collaboration with Benjamin H. Hager, B.S., M.D., Associate in Section on Urology, Mayo Clinic. Second edition, revised and enlarged. Cloth. Price, $13.00. Pp. 480, illustrated with 759 roentgenograms. Philadelphia and London: W. B. Saunders Co., 1927.

Röentgendiagnostik in der Chirurgie und ihren Grenzgebieten. (Roentgen Diagnosis in Surgery and Related Fields.) Von Dr. Hermann Meyer, Privatdozent für Chirurgie an der Universität Göttingen. Paper, price 48 Reichsmark; Bound, price. 50.70 Reichsmark. Pp. 610, with 655 illustrations, Berlin: Julius Springer, 1927.

Einstellung zur Röntgenologie: Eine Untersuchung über die Einfügung der Röntgenstrahlenanwendung in Praxis, Forschung und Unterricht. (Preparation for Roentgenology: A Study on the Introduction of Roentgenological Applications in Practice, Research and Instruction.) Von Prof. Dr. G. Holzknecht. Paper. Price, 8.60 Reichsmark. Pp. 115, Wien: Julius Springer, 1927.

INTERNATIONAL ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

[ROENTGEN DIAGNOSIS]

Abbati, Pietro. Postoperative peptic ulcer of the jejunum in the roentgen picture. *Radiol. med.*, July, 1927, xiv, 575–583.

The author describes and gives illustrative roentgenograms of 2 cases of postoperative peptic ulcer of the jejunum. The roentgen symptomatology is similar to that of gastric and duodenal ulcer. The patient should be examined in many positions and with many projections so as to show the gastroenterostomy opening which is often hidden in the shadow of the stomach and also so as to show a possible small niche which might not be seen except in the projection in which the rays strike it at a tangent. The use of the modern clinoscope which makes it possible to examine the patient in different positions in rapid succession is a great aid in diagnosis. The taking of a rapid series of roentgenograms also makes it possible to show transitory signs which may be of value in diagnosis. In the great majority of cases postoperative peptic ulcer of the jejunum can be definitely diagnosed by roentgen examination. Only the direct signs, such as niche and spasm are of decisive value, just as in ulcer of the stomach and duodenum. Indirect signs are of value only in showing the probable existence of the ulcer.

Arkusski, J. I. Orthodiagraphy of the child's heart and aorta. *Ann. de roentgenol. et radiol.*, 1927, ii, 184–197.

Tables are given showing the orthodiagraphic measurements of the hearts of a large number of children and also the heart measurements as compared with other bodily measurements. The author concludes that orthodiagraphy and also teleroentgenoscopy are valuable aids in clinical examination in determining the volume and outlines of the heart and aorta. All the measurements of the orthodiagram are equally important in judging the condition of the heart. Brugsch uses what he calls the heart relation in determining the volume of the heart. It is the proportion of the volume of the heart to the volume of the body. The author thinks this index is not reliable because the volume of the heart depends not only on the volume of the body but also on many other factors, such as height, blood pressure, condition of the endocrine glands, etc. But for practical purposes one of the more constant body measurements may be adopted as a basis for heart measurements. He finds that the most constant measurement and the one best adapted for this purpose is the sitting height. The heart of the child is comparatively larger than that of the adult.

Arkoussky, J. I. Roentgen diagnosis of congenital lesions of the heart. *Ann. de roentgenol. et radiol.*, 1927, ii, 254–270.

There has been a good deal of discussion of the significance of the different curves in the roentgen outline of the heart. The author finds that in making a roentgen examination in the anterior position the most accessible organs are the left ventricle, the left auricle, the pulmonary artery, the aorta and the right auricle. As the cardiac disturbance in the most frequently acquired heart lesions affect the work of the left ventricle and auricle particularly it is natural to describe the appearance of the heart outline always according to the form of the left ventricle and the whole left outline of the heart. There is, for instance, a parabolic form (normal), a hyperbolic form (particularly in mitral insufficiency) and an elliptical form of the left ventricle (aortic stenosis, sclerosis, etc.).

The author has studied the following cases of congenital anomaly of the heart: 2 cases of open foramen ovale, 4 cases of defect of the ventricular septum, 1 case of stenosis of the pulmonary artery, 4 cases of association of a pulmonary stenosis with Roger's disease, 9 cases of open Botalli's duct, 1 case of stenosis of the isthmus of the aorta, 2 cases of dextrocardia. All of the first five of these classes of lesions affect the right ventricle which first hypertrophies and may then dilate. This as well as increased pressure in the lesser circulation causes a protrusion of the arch of the pulmonary artery. So protrusion of this arch is not pathognomonic of open Botalli's duct, as some authors report.

Cases of these various lesions are described and illustrated by orthodiagrams.

Barcaroli, Italo. A case of hydronephrosis from kink of the ureter secondary to ptosis of the kidney. The usefulness of pyelography in diagnosis and treatment. *Arch. ital. di urol.*, May, 1926, ii, 615–620.

A patient of forty-five had had a feeling of weight in the left kidney region for about a month. Three days before admission he had had an attack of intense pain suggesting colic

from kidney stone. The left kidney did not seem to be enlarged and roentgen examination did not show any stone. Pyelography on the left side showed a mobile kidney of the 2d degree with marked dilatation of the pelvis and chief calyces. There was an N-shaped kink of the upper part of the ureter. Nephropexy was performed and a roentgen examination afterward showed a normal course of the ureter and a decrease in the hydronephrosis of the pelvis and calyces.

The author thinks that pyelography should be practiced more frequently in all cases of vague abdominal pain for which no cause can be found because it will show a very slight dilatation of the pelvis which would not be suspected clinically and permit of surgical operation in the early stages of a hydronephrosis which will prevent the development of more serious lesions, and may also prevent a mistaken diagnosis of cholecystitis, appendicitis or disease of the adnexa.

Becchini, Gastone. Heat measurements and constitution. *Radiol. med.*, June, 1927, xiv, 459–476.

Two hundred Italian subjects were examined by the author with a view to determining the relations between the size of the heart and constitution. One hundred of them had normal hearts and 100 had various forms of cardiac disease. He found that there is a definite relationship between the normal measurements of the heart determined by the orthodiagram and the different types of constitution worked out by Viola. He found that in the majority of cases of simple compensated mitral lesions the measurements had the same proportion as in normal subjects but this was not true of other heart lesions and they could not be classified in any of the groups. In addition to the absolute values for each diameter of the heart he established an index value for each of the heart diseases. This index value is the proportion between the absolute value of the diameter and the transverse diameter of the thorax and he thinks that it will be of great value in roentgen diagnosis in cases where the relative value is of more importance than the absolute value. He also tries to establish proportionate values for the two ventricles and values for the inclination of the heart.

Bottoni, Enzo. The roentgen picture in hemoptysis with special reference to differential diagnosis between hemoptysis from mitral stenosis and from pulmonary tuberculosis. *Arch. di patol. e clin. med.*, May, 1927, vi, 258–279.

Case histories and roentgenograms are given of 8 cases of hemoptysis from mitral stenosis or pulmonary tuberculosis or a complication of the two and certain points in differential diagnosis pointed out. In tuberculosis even before there are any clinical signs foci of bronchopneumonia develop which show on the roentgen plate as small round opaque spots the size of pinheads or a little larger with slightly indistinct outlines and generally accumulated in a limited area; sometimes they are confluent. These spots are one of the first roentgen signs of beginning tuberculosis. Of course as the disease progresses the signs will be more marked. There is also a phthisic habitus. Individuals of this type are tall and slender with long bones and a long, narrow chest. The roentgen picture shows greater transparency of the chest than usual because of the smaller amount of soft tissues and the smaller blood supply, and a small drop heart. Another phenomenon, and one which might be confused with mitral lesion, is that in the anteroposterior projection there is an accentuation of the auriculopulmonary curve similar to that of mitral stenosis.

In a hemoptysis due to mitral stenosis the roentgen picture will show the signs of that heart lesion. In the heart picture taken in the sagittal direction the auriculopulmonary arch of the left heart, which in the normal heart is much less prominent than the arch of the descending aorta and the apex, is accentuated so that it makes up the greater part of the left outline of the heart. Sometimes this arch is not much more curved than normal but is simply elongated so that the point where it joins the ventricle arch is much lower down. The arch is not formed by the enlarged left auricle, as some authors believe, but by the pulmonary artery. In the right outline of the heart the lower part is longer and more arched than normal. Roentgen examination in the oblique position shows the most important sign of this lesion, namely a dilatation of the left auricle. But pure mitral stenosis is generally congenital; in the acquired cases it is accompanied by insufficiency. So the roentgenoscopic examination in the oblique position shows the protrusion of the left auricle in the retrocardiac space in pure stenosis and in combined cases another protrusion due to enlargement of the left ventricle, continuing in a single arch with the auricle arch, so that the whole length of the retrocardiac space is occupied by it.

The pseudo-mitral heart of tuberculosis shows an accentuation of the auriculopulmonary curve in the anteroposterior projection,

but in the oblique position there is no protruding shadow to show enlargement of the left auricle, for there is no dilatation of that cavity. The increased auriculopulmonary arch in pseudomitral heart is due to enlargement of the conus arteriosus of the pulmonary artery from passive congestion in the lungs. In such cases there are no signs of mitral lesion on auscultation or percussion.

Potain says that pulmonary tuberculosis and mitral stenosis are rarely if ever seen in the same case. But the author has seen 5 such cases and thinks they are not so rare as is commonly believed. One of his cases showed the roentgen picture of both diseases but he concluded that the hemoptysis was due to the mitral lesion because the pulmonary lesion was an old calcified one and there were no signs of regressive tuberculosis such as would have caused hemoptysis.

CASATI, ANNIBALE. Displacement of the esophagus. *Radiol. med.*, July, 1927, xiv, 593–601.

The cervical part of the esophagus extends down to the first rib, the thoracic part from there to the esophageal opening in the diaphragm and the abdominal from there to the stomach. The cervical portion is relatively the most fixed and the thoracic part the freest so that displacements of the latter are found most frequently. Displacements of the esophagus may be true displacements of the esophagus alone or false displacements due to displacement of the mediastinum. Displacements of the esophagus may also be temporary or permanent. Temporary displacements occur in pneumothorax or pleural effusions and in various pathological conditions of the thorax, such as goiter, aneurysm, tumors of the mediastinum, etc. Permanent displacements are due chiefly to cicatrization, mostly of the pleura. The adhesions may act directly on the wall of the thorax or indirectly through the surrounding connective tissue. The forms due to pleural adhesions at the apex are varied and interesting. There are certain displacements due to pressure of an organ but they may be permanent after removal of the organ on account of adhesions that have formed, as for instance postoperative deviations due to retrosternal goiter when the goiter has persisted for many years. The deviations may affect all or a large part of the esophagus or only a small part of it. The former generally occur in total displacement of the mediastinum while the displacements of a small part of it are due to propulsion from a neighboring organ or traction by scar tissue. Those from propulsion are generally round and follow the outline of the organ which produced the pressure while those from traction are angular. The most common ones are those caused by traction of the pleura, especially at the apex, while the most interesting ones are those due to inflamed lymph glands as they may cause a diverticulum of the esophagus. These displacements do not cause any subjective symptoms. Displacements of the esophagus may also be caused by kyphoscoliosis and by enlargement or displacement of the heart and large vessels.

CORRERA, T. Roentgen study of the pleura with cranio-dorsoventral projection of the thorax. *Radiol. med.*, July, 1927, xiv, 553–564.

The standard technique which is in use at present for roentgen examination of the thorax shows the lungs and the hilus region but not the pleura, which does not give any shadow either on the screen or plate. The author therefore proposes a modification in technique which consists in changing the inclination of the tube and that of the plate so that the bundle of rays strikes the negative obliquely, following the obliquity of the ribs. He calls this the cranio-dorsoventral projection. In a roentgenogram obtained in this way the lateral outline of the thorax is not formed by the crossing of the ribs; the ribs run in a horizontal direction so that the anterior costal arch is projected on the posterior costal arch, forming an unusual design which is illustrated. Between the ribs in the free intercostal space the parenchyma of the lung can be seen covered by a band of opaque tissue which represents the pleura. This line which normally grazes the internal outline of the rib is separated from it if there is a thin layer of liquid or a thickened and indurated pleura.

The author has made comparative examinations by the standard method and by his method in patients with pleurisy; a number of the cases are described and the roentgenograms reproduced. He shows that thickening of the parietal pleura which does not show in an ordinary roentgenogram shows very clearly in the roentgenograms made by his method. His method also shows that when there is a liquid effusion at the base the pleural fluid reaches a considerable height, and in some cases even covers the apex of the lung.

GIOVETTI, V. Renal calculus and pyelography. *Arch. ital. di urol.*, Jan., 1927, iii, 253–257.

A woman forty-five in 1917 had intense pain in the right hypochondrium and high fever. This was followed by other attacks which kept her in bed for a month. Examination of the

urine showed pus and she was treated for cystitis. She then had alternating periods of good health and attacks of colic. In 1920 a roentgen examination was made but did not show any signs of kidney stone. In July, 1926, she came to the author on account of repeated severe attacks of colic and temperature to 39°. Examination of the urine showed pus, albumin and many erythrocytes and leucocytes. Roentgen examination showed a shadow but it was impossible from its position to make a definite differentiation between kidney stone and gallstone. Pyelography was then performed and the pyelogram is reproduced. The pelvis and calyces were perfectly injected on the left, while on the right only the pelvis and the lower part of the calyces was injected. The passage of the opaque liquid into the upper part of the calyces was evidently prevented by the stone which lay in a different position from what it had on the roentgen examination. There was no longer any doubt that it was a movable renal calculus. The patient suffered no inconvenience from the pyelographic examination which is perfectly harmless when properly performed.

Giuntini, L. Primary myxochondrosarcoma of the astragalus. *Arch. di ortop.*, 1926, xlii, 89–96.

A man of thirty-nine had been suffering for about nine months from a lesion of the right foot; it had been diagnosed as tuberculous and he had been treated at a sanatorium without any effect. Roentgen examination of the tibiotarsal region showed the external malleolus enlarged and deformed with a certain amount of rarefaction of the trabeculation, especially in the metaphysis. The cortex of the lower third of the diaphysis of the fibula showed a thickening on the posterior side in the form of a slender ridge. There was a large swelling on the external side of the astragalus; it was polycystic in structure and bounded by a thin cortex which disappeared on the lower side where the outline of the bone was indistinct. There was severe deformity of the body of the astragalus which looked as if the posterior half of it had been crushed, with complete disappearance of normal trabeculation and substitution of a shapeless mass, not very transparent to the rays but distinctly demarcated from the normal bone. A characteristic feature was the integrity of the joint surfaces in spite of the severe bone changes described above.

As microscopic examination of an excised piece of the tumor showed sarcoma cells an amputation of the lower third of the leg was performed.

Lussana, S. Fracture of the ankle. *Arch. di ortop.*, 1926, xlii, 155–392.

Fractures of the ankle may involve the lower end of the tibia and fibula up to 7 to 8 cm. above the malleoli. They may be fractures of a single malleolus, bimalleolar fractures, Dupuytren's fractures or supramalleolar fracture. Generally they are caused by indirect violence. They are caused either by forced abduction or forced adduction of the foot, the former more frequently than the latter. These movements are combined with various degrees of torsion on the axis of the leg and rotation of the foot. In bimalleolar and low Dupuytren's fracture there may be external deviation of the foot without separation of the fragments of the tibia and fibula. The two fragments of the malleolus are displaced outward and the astragalus follows them. Frequently the external deviation is accompanied by a certain degree of posterior subluxation of the foot. The reason for this is a lesion of the posterior margin of the tibia. When there is no diastasis the posterior marginal fragment is detached from the tibia by a tangential push of the astragalus in a position of forced plantar extension of the foot and the fractured posterior marginal tract forms a single fragment with the internal malleolus. Posterior marginal fracture changes the system of support and causes posterior deviation of the foot while bimalleolar fracture causes a valgus deviation because of the incongruity between the center of pressure and the center of support on the joint surface of the tibia or that of the astragalus. In low Dupuytren's fracture without diastasis posterior subluxation of the foot is the more frequent deviation and always more marked than the valgus deviation. There may be a lesion of the anterior margin of the tibia and very rarely of both margins at the same time. Diastasis of the lower end of the tibia and fibula is caused by laceration of the tibioperoneal ligaments or avulsion of bone at the insertion of the posterior ligament which is stronger than the anterior one. Diastasis is almost constant in typical Dupuytren's fracture. When there is both diastasis and a posterior marginal fragment of the tibia the latter is always a postero-external fragment, that is, it corresponds to the tibial insertion of the posterior tibio-peroneal ligament and has been broken off not by a tangential blow of the astragalus but by tension on that ligament in forced abduction of the foot. In fractures in which there is evident diastasis the external deviation of the foot always predominates over posterior subluxation. But

sometimes a Dupuytren's fracture shows a maximum backward dislocation without apparent diastasis. A search should be made on the roentgen screen for this masked lesion of the tibio-peroneal ligaments after the dislocation is reduced; on pushing the foot outward the diastasis will be seen. Among supramalleolar fractures also there are ones without displacement of the fragments, ones with only lateral deviation of the foot and ones with both lateral and anteroposterior deviation. A lateral deviation may be either valgus or varus, depending on the direction of obliquity of the fracture line of the tibia and the difference in level between it and the fracture line of the fibula, as a result of which the lower fragment may slide on the upper one either medially or laterally. The lateral deviation may be accompanied by anteroposterior deviation, producing a deformity in the shape of an arc of a circle, open either forward or backward. The outcome of fractures of the ankle is frequently that of other joint fractures: rigidity of the joint, progressive traumatic arthritis, arthritis deformans, ankylosis and vicious consolidation. The most frequent forms of vicious consolidation are talipes planovalgus, talipes varus, talipes equinus, talipes equino-valgus, and a bend of the lower third of the leg in an arc of a circle. Talipes planovalgus is the most common outcome of bimalleolar and Dupuytren's fracture.

Roentgen examination is often necessary to supplement clinical examination and show these different types of fracture. Many diagrammatic sketches and roentgenograms of the different forms of fracture are given. Roentgen examination is also necessary in following up the course of the recovery and determining the degree of invalidism resulting from vicious consolidation. In mild cases with good position of the foot, moderate rigidity of the joint, little edema and pain and slight atrophy of the muscles the indemnity should be 10–15 per cent; in moderate forms with slight valgism, foot at a right angle with considerable rigidity, edema, pain and marked atrophy 15–30 per cent; in serious forms with marked valgus or valgo-equinus, and serious arthritis developing toward ankylosis 30–50 per cent.

Milani, Eugenio. Analysis of the pain in hepatic colic under roentgen observation. *Arch. di radiol.*, Jan.-Feb., 1927, iii, 228–239.

The pain in hepatic colic is generally attributed to an effort on the part of the gall-bladder to expel the stone. The author had occasion to make a roentgen examination of a patient who had had hepatic colic and after the contrast medium had been administered a violent attack of pain came on which lasted twelve hours. Roentgen examinations were made during the attack. The gall-bladder did not change form during the colic. There was complete suspension of stomach peristalsis, the pylorus remained closed and the action of the jejunum was suspended. There was diffuse abdominal pain in addition to the local pain over the gall-bladder.

The lack of any change in the form of the gall-bladder during the pain or when the pain was controlled by morphin seems to indicate that the pain is not an expulsive pain of the gall-bladder. The closing of the sphincter and the suspension of passage of stomach contents into the duodenum was probably a defense reaction, as was also the suspension of peristalsis in the duodenum, jejunum, ileum and colon and the closure of the sphincter of the common duct. The object of this defense mechanism is not very well understood. The spasm and pain may be due to disequilibrium in the vagus-sympathetic system which traverses the solar plexus and presides over gastric and duodenal function. In the few cases that have been examined during the attack there has always been spasm of the pylorus or spasm of the whole stomach.

Pincherle, Pino. Changes in the base of the skull in forms of osteitis. *Radiol. med.*, June, 1927, xiv, 446–458.

Pincherle has studied the changes at the base of the brain in a number of cases of osteitis. In Paget's disease there is a more or less marked osteoporosis; the normal profile is preserved, the pneumatization of the sinuses and mastoid cells is normal, the sella is normal in size and form. In advanced cases there is convexity of the base from elevation of the posterior fossa while the spinal column supports the weight of the enlarged skull normally. In Recklinghausen's disease there is no change in the profile of the base. In localized osteitis only the part affected by the process of hyperostosis is different from normal in appearance. Often the normal parts are there but covered by new-formed bone which is superimposed on them. The most extensive and most important changes are found in diffuse hyperostosis; they often cover large parts of the base and sometimes the whole of it. Bone substance less resistant than normal and without structure is superimposed on the bones of the base; it partially fills the sinuses and obliterates the sulci and vessel canals. The predominant

appearance is that of eburnation. The skull cavity is reduced in size by this new-formed bone; it causes nerve disturbances from lesions of the centers or strangulation of nerve trunks. It is important not to confuse diffuse hyperostosis with Paget's or Recklinghausen's disease or with osteomalacia. A roentgen study of the different appearances of the bones of the skull in different diseases helps in the differential diagnosis of processes in other bones of the body.

Pisani, Luigi. Surgery of horseshoe kidney with special reference to pre-operative diagnosis. *Arch. ital. di urol.*, Oct., 1926, iii, 97–112.

In a previous article the author described 7 cases of horseshoe kidney which he has operated upon and in this article he gives the case history and roentgenograms of an eighth. He finds that Rovsing's classical syndrome is rarely present in this condition except in certain non-pathological cases. Generally the cases show no symptoms for years, unless they are those of some ordinary complication. Pain is sometimes complained of, but whether it is a localized kidney pain or a diffuse abdominal pain the author thinks it is due to disturbance in the flow of urine or to pressure on the vessels and their sympathetic plexuses. The preoperative diagnosis is always very difficult and can rarely be made from the clinical symptoms alone, either because the kidney cannot be palpated or because the symptoms of some complication mask those of the condition itself. The most important signs are furnished by roentgen and pyelographic examination. The simple roentgenogram is not of absolute value, however, except in the cases in which the kidney shadow is very clear; it should be practiced on both sides, preferably with an opaque catheter in the ureter. The kidney shadows are lower and more median than normal and oblique from above downward and from without inward. The one on the well side was clearer in the author's case than the right one which contained a calculus. The examination had been made for calculus and not because horseshoe kidney was suspected. The shadow of the ureteral catheter diverges from below upward and from within outward. The pyelogram always gives pathognomonic pictures but must be practiced on both sides also, because it may be negative on the diseased side if there are deformities of the pelvis from the disease. The pyelogram is absolutely conclusive in non-pathological horseshoe kidney and in pathological cases on the normal side, showing the characteristic orientation of the pelvis. The shadow of the pelvis is lower than normal and closer to the spinal column and symmetrical with that of the opposite side. The obliquity of the ureter is the reverse of its normal direction.

Santoro, Mario. Large abscess from suboccipital disease. *Radiol. med.*, July, 1927, xiv, 564–568.

Tuberculosis of the occipital condyles and the atlas and axis causes a variety of tuberculous spondylitis which is characterized by special functional disturbances and in which there is danger of compression of the medulla oblongata. Lannelongue gave this the name of "suboccipital disease" and according to him cold abscesses are relatively rare in it because it develops so rapidly that the patient dies before the tuberculous foci become externalized. Such abscesses have little tendency to migrate. Lannelongue only saw one case in which an abscess extended into the mediastinum and caused death by compression of the trachea.

The author describes a case in a boy aged twelve who presented an enormous retroesophageal abscess which filled both supraclavicular spaces, which caused only slight clinical symptoms and no fever and did not interfere very greatly with lateral movement of the head. A roentgenogram showed erosion and flattening of the arches of the atlas, a slight diastasis of the arches between the atlas and axis, and one of the rare findings in this disease, namely, a lateral obliquity of the posterior arch of the atlas which was so pronounced as to make it impossible to distinguish the two halves of the arch. This confirmed the clinical diagnosis of tuberculous spondylitis and established its localization. Pus obtained by puncture showed the microscopic characteristics of tuberculous pus.

Schiassi, F. Distribution of the fluid in the pleural cavity. *Arch. di patol. e clin. med.*, Feb., 1926, v, 1–21.

A study of a case of serofibrinous mediastinal pleurisy convinced the author that effusions of the mediastinal pleura are not always encysted and that a serofibrinous effusion may sometimes be formed and kept up in the mediastinal pleura even if it is not held there by adhesions. To show that this was true he introduced 2 c.c. lipiodol into the liquid of a posterior mediastinal pleurisy which was shown by a triangular zone of right paravertebral dullness. It descended to the bottom of the posterior costomediastinal sinus. In right lateral oblique decubitus the lipiodol lay at the bottom of the

costodiaphragmatic sinus next to the lateral wall of the thorax. In left lateral oblique decubitus it returned to the costomediastinal sinus. The author believes that in this case, as in the others that he has studied, the serofibrinous effusion remains in the mediastinal pleura because it is kept there by the adhesion of the two folds of the pleura, possibly increased by inflammation.

As lipiodol is known to be harmless the author introduced it into the pleural cavity to determine whether, unlike transudates, serofibrinous exudates do not move, or only very little, on change of position because they are held in place by adhesions which form rapidly. He chose 2 cases of pleurisy with only moderate effusion and after having made an exploratory puncture he injected 2 c.c. lipiodol diluted with 4 c.c. almond oil into the pleural cavity. On changing the position of the subject the lipiodol moved to all parts of the pleural cavity, even up to above the apices, following the law of gravity. All these points are illustrated by roentgenograms. He concludes that the reason for the immobility or slight mobility of free liquid pleural exudates on decubitus does not lie in the rapid formation of adhesions but in other factors, chief among them adhesion of the two folds of the pleura, possibly increased by inflammation.

Stern, N. E. Roentgen diagnosis of diverticulum of the esophagus. *Ann. de roentgenol. et radiol.*, 1927, ii, 173–183.

Since the introduction of roentgenoscopy all other methods of diagnosis of diverticulum of the esophagus have practically been given up, as it is simpler and much less troublesome to the patient. The author has examined 9 cases between 1900 and 1924. Eight of them were in men and 1 in a woman. All of the patients except 1 were between forty and fifty-six years of age. He uses a barium emulsion for the examination rather than a barium paste because the liquid enters the diverticulum more readily. It is best to make the examination in the first oblique diameter with a small diaphragm. The examination generally shows a saccular dilatation with sharp outlines. Often the whole contents of the diverticulum can be pressed out and on observation on the screen in the first oblique position the barium can be seen passing out of the diverticulum and down the esophagus. A differentiation must be made between diverticulum, cancer stenosis and idiopathic dilatation of the esophagus. It is not very hard to exclude the latter as the barium in dilatation fills the esophagus in a broad band that narrows toward the cardia. In constriction of the esophagus from cancer the barium generally passes slowly down to the site of the constriction and stops. The outlines of the esophagus are rarely changed; above the constriction there is generally a considerable dilatation while below it the canal is narrower. And in almost all cases there is antiperistalsis. It is hard to differentiate low pulsion diverticulum and traction diverticulum from cancer stenosis. In 8 of the author's 9 cases the diverticulum was at the typical site just at the transition from the pharynx into the esophagus but the other was a low traction diverticulum. He succeeded in introducing a Rosenheim's spiral sound beside the diverticulum, showing in this way that it was a true diverticulum and not a cancer stenosis.

The course of the disease is very slow and the patients finally die of starvation if operation is not performed in time. He thinks a roentgenoscopic examination should be made in every case of difficulty in swallowing so that early operation may be performed if necessary.

Tartagli, Dino. A traumatic lesion of both wrists. *Radiol. med.*, July, 1927, xiv, 569–574.

The patient while working on a building was knocked down by some sacks of sand which fell on him. He made an instinctive movement of defense by holding up both arms with his hands spread out and the sacs struck his hands, causing distortion of both wrists. He did nothing about it for several days until he found that the limitation of movement of his wrists was increasing rather than decreasing. When the author saw him he presented edema of both wrists and hands without ecchymoses and the ends of his fingers were semiflexed. Roentgen examination showed anterior dislocation of the semilunar and scaphoid on both sides caused by the hyperextension of the hands.

Vallebona, Alessandro. The combined method of cystoroentgenography in hypertrophy of the prostate. *Radiol. med.*, June, 1927, xiv, 494–508.

The different methods of examination in hypertrophy of the prostate are briefly described—rectal examination, cystoscopy, urethroscopy and ureterography—and the value of cystography in diagnosis shown. The author reviews the methods of cystoroentgenography which are in use, such as pneumocystography and cystography with the aid of opaque substances, and then describes his combined technique, which he has already described in previous articles, and which consists in introducing into the bladder a small amount of

dense suspension of barium sulphate and then insufflating the bladder. Before making the roentgenogram the patient is turned in different positions so as to get a uniform stratification of the opaque medium on the walls of the bladder which makes them visible on roentgen examination when they are struck tangentially or almost so by the rays. In using the combined method he attributes much importance not only to the projection but also to the position of the patient. The patient must be made to take such a position that the part of the bladder to be examined is not hidden by the opaque substance which collects in its most dependent part. The projections which are best for studying the trigone and all the lower part of the bladder are the psoteroanterior and the anteroposterior. In the posteroanterior projection the patient bends forward and the foot of the bed is raised or he may lie on one side with a horizontal incidence of the rays. The anteroposterior projection with the patient leaning forward also has certain advantages.

He concludes that the combined method is superior to others in studying intravesical development of the prostate and cites two examples: the first was a case in which ordinary cystography did not show the hypertrophy of the prostate but it was shown by the combined method and the diagnosis confirmed on operation. The second case showed the importance of a negative result obtained by the combined method. In fact, when the results are negative the value of the method is absolute, while the ordinary method even when it is negative does not absolutely exclude the possibility of an intravesical projection of a prostatic adenoma. The author also shows the advantages of the combined method in examining papillomas, tumors and diverticula of the bladder.

Vietti, Marco. Roentgenoscopic and roentgenographic examination of the gall-bladder in the erect position. *Radiol. med.*, June, 1927, xiv, 508–523.

The author advocates examining the gall-bladder without any opaque medium and with the patient standing. It is obvious that this is the best position for examining an organ that is pendant like the gall-bladder. He describes the technique which he uses and the differential signs between the shadow of the gall-bladder, that of the kidney and that of Riedel's lobe. The gall-bladder can be differentiated from Riedel's lobe by the fact that it is intersected by a more opaque line marking the lower border of the liver and by the fact that in hypertrophy of the liver localized in Riedel's lobe the angle which the right border of the liver makes with the external margin of the gall-bladder is replaced by a curved line. He reports several cases in which his findings have been verified by surgical operation.

Violato, Andrea. The supernumerary bones of the tarsus. *Arch. di ortop.*, 1926, xlii, 501–521.

Supernumerary bones of the tarsus differ from sesamoid bones in having no function. Some of them are simply atavistic rests, others result from centers of ossification of neighboring bones which have not united with the principal bone and some are a regressive anomaly as they are found in lower orders of animals. These bones are interesting not only anatomically but also clinically as they may become the site of fracture or of acute or chronic inflammation. Since the introduction of roentgen examination of course they have been found much more frequently than before. Pfitzner says that supernumerary bones are found in 25 per cent of human feet.

The author describes 3 cases with roentgenograms, in one of which there was a trigone bone or accessory astragalus and in the other two Shepherd's fractures. The first patient was a man of thirty-four who was excavating when a bank fell on him and he was thrown forward on his face while his foot remained fixed. He felt intense pain in the left ankle and could walk only with great difficulty. The roentgenogram in a lateral position showed a mass of bone isolated from the adjoining bone in the angle formed by the posterior edge of the calcaneus and the posterior edge of the astragalus. It was scaphoid in form and separated from the calcaneus and astragalus by a zone which looked like a joint interline. The outline of the posterior part of the mass was irregular. This was a case of supernumerary astragalus and not of fracture. In the other foot the posterior tubercle of the astragalus was hypertrophied but there was not a distinct trigone bone.

The second patient was a man of thirty-two who fell from a height of about 3 meters and struck violently on the calcaneus of his left foot. The roentgen examination in this case showed a true fracture line between the body of the astragalus and the posterior tubercle.

The third patient was a workman of thirty-five who fell from about 3 meters. His right foot was caught between two beams and held while his body was thrown to the right. The roentgenogram showed a comminuted fracture of the internal malleolus and a fracture of the posterior tubercle of the astragalus. This patient also had a trochlear process of the astra-

galus on both sides, more developed on the right, which had not caused any clinical signs or disturbance of function.

Viviani, Rodolfo. Tuberculosis of one lung and active hyperemia of the other. *Radiol. med.*, June, 1927, xiv, 476–483.

The patient was a man of twenty-six whose father and a sister had died of pulmonary tuberculosis. He had been well until three months before the examination when he began to have cough, night sweats and evening rise in temperature. Roentgen examination showed a large cavity in the left lung with other signs of specific bronchopneumonia. On the right there was a change in the lung outline caused by shadows which were interpreted as being signs of tuberculosis, particularly as there were some slight clinical signs in this lung too. Autopsy confirmed the results of roentgen examination as far as the left lung was concerned but it showed that there was no organic lesion on the right either macroscopically or microscopically. The changes in the lung outline therefore had probably been caused by engorged vessels due to active hyperemia. The author emphasizes the importance of this case in showing that certain roentgen findings, even rather intense ones, may only show functional changes. The roentgenologist should always bear this in mind and be very careful in interpreting such findings. He intends to make a very careful study of the hyperemic lung and the circumstances which might cause such a picture as the one seen in this case.

Alvarez, Walter C. Reverse waves in the pars pylorica of the stomach. *J. Am. M. Ass.*, Feb. 12, 1927, lxxxviii, 472–473.

From time to time during the past few years there have been observed waves of reverse peristalsis which can start at the pylorus and run orad over the antrum, particularly when there is back pressure in the small bowel due to mechanical or dynamic obstruction. These waves appear sometimes when a reverse wave in the duodenum approaches the pylorus and they thus give an impression of being a continuation of that wave. Occasionally such waves have been observed roentgenoscopically in man, particularly in cases of duodenal ulcer associated with some obstruction at the pylorus. There the conditions are somewhat similar to those produced in the animal experiments.

A student of intestinal obstruction will be interested to find that reverse waves may run over the stomach early in the course of a mild dynamic obstruction low in the bowel. The intestinal contents do not ordinarily go down the bowel to pack up against the obstruction. The bowel immediately above the obstruction is often empty and the most striking signs of stagnation are noted in the duodenum. It was this back pressure, distending the duodenum, which seemed to give rise to the reverse peristalsis in the antrums of the stomachs studied. Hence it is probable, that nausea and vomiting can take place early in the course of intestinal obstruction long before the bowel has shown any signs of filling up orad to the lesion.

Asbury, Eslie. Spondylolisthesis. *J. Am. M. Ass.*, Feb. 19, 1927, lxxxviii, 555–562.

Spondylolisthesis although not a common condition occurs often enough to be of practical importance in the differential diagnosis of backache. The normal anatomy, embryology, and function of the lumbosacral joint are factors in the causation of the subluxation. This is strikingly shown by the frequency of subluxation of the 5th lumbar vertebra secondary to Pott's disease, whereas tuberculosis of other vertebrae does not often cause this type of subluxation. The pathologic change consists in a subluxation either of the body or of the whole vertebra, the former being the more common.

The onset of symptoms may be either gradual or sudden. If sudden, the cauda equina is more apt to be injured because the cases with sudden onset are usually associated with severe trauma. If the onset is gradual the nerves have a better chance to adapt themselves in the neural canal, which is very roomy at this point. A constant feature in the history is the disappearance of the dull boring backache and radiating sciatic pains on abstaining from exertion for a few days with the sudden reappearance of symptoms when work is resumed. The telescoped, shortened trunk with the extreme lordosis of the lumbar spine, the concavity above the sacrum and the prominent upper border of the sacrum or pseudokyphos are the outstanding features to be seen in the examination of a patient suffering from spondylolisthesis. The inclination of the pelvis is lost and the birth canal is narrowed at both the inlet and outlet. Signs of a partial caudal lesion are frequent but a complete lesion is rare because only the body of the vertebra is dislocated in most cases.

Some stabilizing operation seems to be the only procedure in the treatment of cases with severe disability, because this prevents further progress of the subluxation and causes the superincumbent weight to rest in a more normal line on the sacrum. In the milder cases

external support seems sufficient to relieve symptoms.

Baum, Felix. A roentgen-ray phenomenon in the normal and pathologic hilum. *J. Am. M. Ass.*, Feb. 26, 1927, lxxxviii, 634–637.

One of the most difficult problems of the roentgenologist is the distinction between the normal and the pathologic hilum. The author considers the hilum abnormal from the anatomic standpoint when the interspace becomes diminished or hazy or filled with a dense shadow. This refers to the characteristic interspace present between the hilum and the heart shadow and is more marked on the right than on the left. In pathologic conditions of the hilum this interspace is changed or entirely absent. It is therefore suggested that an exact description of the interspace should be given in every roentgen-ray examination of the chest. Especially in the very rare cases of isolated hilum tuberculosis in adults the interspace is absent or changed. The interspace might be present in even far advanced cases of pulmonary tuberculosis without the involvement of the hilic glands. The disappearance or change of the interspace may be due to inflammatory conditions, tumor of the hilum, circulatory changes in the branches of the pulmonary artery or enlargement of the right heart.

Beye, Howard L. Transphrenic infection. *Arch. Surg.*, January (Part II), 1927, xiv, 240–260.

The diaphragm presents a unique barrier to the spread of infection from the pleural cavity. Extension through it in cases of empyema or lung abscess is remarkably infrequent. In infection originating below and in contact with the diaphragm the likelihood of the process passing upward to involve the pleural cavity or lung parenchyma is distant. This is explainable on the basis of the lymphatic drainage of the diaphragm. An uncomplicated subphrenic abscess will often present a clinical problem which is difficult to interpret and treat. This is likely to be greatly increased when the condition is complicated by an extension of the infection above the diaphragm to the pleural space or lung.

For diagnosis a carefully taken history with special stress laid on etiology is of the greatest importance. In the chronic or latent cases with the history of an acute abdominal insult such as perforation of a peptic ulcer or acute appendicitis, one should always suspect the presence of a subphrenic infection even though the symptoms are referable to the thorax. The roentgen-ray study must be thorough. One may easily overlook evidence of a subphrenic abscess when concentrating attention on an intrathoracic pathologic condition. The roentgen ray may be misleading, however, if depended on too much. Lung mapping will help in certain cases. Tenderness under the costal margin and in the flank, and in the wall cannot be passed over too lightly in cases in which the pathological condition is seemingly all above the diaphragm. A gross break in the diaphragm takes place in the majority of cases with a direct connection between an infraphrenic and supraphrenic involvement. Drainage of either the infraphrenic or supraphrenic infection will lead to the cure of both in some cases. Drainage of each area of involvement will be necessary in most cases. Ten case reports are given.

Braasch, William F., and Cathcart, Edward P. Clinical data and prognosis in cases of chronic pyelonephritis. *J. Am. M. Ass.*, May 21, 1927, lxxxviii, 1630–1633.

Of the various lesions affecting the urinary tract in the adult, chronic pyelonephritis furnishes the greatest problem to the urologist. This type of disease is usually bilateral and resists all specific therapeutic measures so far advanced. The primary roentgenogram in cases of chronic pyelonephritis is usually not of much clinical value. A stone forming tendency which is apparently secondary to the chronic renal infection is however occasionally observed. In most cases the stones were small, and in several cases were passed spontaneously. Occasionally multiple minute calcareous areas are visible in the renal area and these on exploration have been found to be caused by particles of sand-like material.

The deformity of the outline of the pelvis and ureter in chronic pyelonephritis is usually typical, being characterized by marked dilatation in the ureter with slight if any dilatation in the pelvis and usually none in the calyces. The typical ureter is dilated irregularly throughout and presents the appearance of multiple areas of constriction. In most cases, however, it would be impossible to ascribe the irregular dilatation to obstruction alone, but rather to the result of chronic inflammation and cicatrization of the ureteral wall. The greatest dilatation is usually observed in the upper third of the ureter and it frequently stops abruptly at the ureteropelvic juncture, leaving the pelvis and calyces intact.

It is generally recognized that there must be a primary focus of infection in most cases of chronic pyelonephritis, and in every case roentgenograms of the teeth should be made, the

tonsils should be investigated, secretion from the prostate or cervix examined and intestinal stasis excluded. The probability of such foci being closely related to the chronic renal infection is evidenced by the acute exacerbation of symptoms frequently observed immediately following the removal of infected teeth and tonsils. Experience has shown that about one-third of the patients with chronic pyelonephritis will recover, another third will be markedly improved, and the remaining third will not be helped by the treatment received.

BROWN, SAMUEL, and WEISS, H. B. Lateral views of the heart and aorta. *J. Am. M. Ass.*, Jan. 22, 1927, lxxxviii, 226–229.

During the past two years the authors have made a study of the heart and aorta and their relationship to the thorax in the lateral view. A study of several hundred thoraces of normal and abnormal persons was made. In such a study it is absolutely essential to obtain a true lateral view in order to observe properly the normal relationship of the thoracic structures and any deviation from the normal. Since only relative values were sought a lateral teleroentgenogram was not essential. The patient was placed with the left side toward the film in either the erect or prone position with the arms elevated above the head. The target of the tube was centered to the middle of the thorax on the opposite side, and an exposure was made of from ½ sec. to 1½ sec., depending on the size of the subject. The usual distance employed between film and target was 3½ ft. More than 20 to 30 ma. was not used, and the spark gap did not exceed 5 to 6 inches.

The lateral view of the thorax enables one to learn that the position of the heart is oblique. The configuration of the heart shadow is oval. Changes in the volume of the heart and of the individual chambers can be recognized. The heart is located in the anterior half of the thorax. There are two transparent triangles due to lung tissue, one situated in front and one in the back of the heart. There is a definite relationship of the heart to the aorta, and of the heart and aorta to the thorax. One can usually trace the aorta from its origin to the diaphragm in most of the lateral films. Any general or local dilatation can be readily seen and loss of parallelism of the aortic borders is easily recognized. The presence of atheromatous changes is evidenced by an increase in the density of the aortic shadow. Under normal conditions the posterior border of the heart does not touch the descending portion of the aorta unless the heart is markedly enlarged.

CHANDLER, L. R., and NEWELL, R. R. Cholecystography and pathologic changes in gallbladder. *J. Am. M. Ass.*, May 14, 1927, lxxxviii, 1550–1552.

In 50 consecutive cases in which cholecystectomy was performed the authors made a comparison of the roentgen-ray observations after the administration of tetraiodophenolphthalein with the pathologic findings. The results are given in a table, and it is concluded from these findings that cholecystography is capable of considerably improving the diagnosis of gallstones. A normal cholecystogram does not necessarily mean a normal gall-bladder. Failure of the gall-bladder to visualize even after intravenous administration of the dye may occur with a nearly normal mucosa and in the absence of gallstones. Smoothness or irregularity of the gall-bladder shadow does not correlate very well with absence or presence of gall-bladder adhesions. The failure of the gall-bladder to empty after a fatty meal is probably a sign of disease.

EISENDRATH, DANIEL N., and ARENS, ROBERT A. Cholecystography in the differentiation of biliary and renal calculus shadows. *J. Am. M. Ass.*, Feb. 26, 1927, lxxxviii, 646.

In a recent case showing a shadow in the right renal area on the ordinary roentgenographic film the question arose as to whether the shadow represented a calculus in the gall-bladder or kidney. A study was therefore made of the relation of this shadow to the cholecystogram. In the ordinary anteroposterior exposure the suspected renal calculus shadow was entirely included in that of the gall-bladder. In another exposure taken at a slightly different angle the shadow projected a little mesially to that of the cholecystogram, thus revealing the fact that the calculus was not in the gall-bladder. In a third lateral view the separation of the shadow of the calculus from that of the gall-bladder was most marked. It is suggested that this method may be of value in cases in which pyelography is either inadvisable or postponed.

EUSTERMAN, GEORGE B., and BUEERMANN, WINFRED H. Carcinoma of the stomach. *J. Am. M. Ass.*, Jan. 29, 1927, lxxxviii, 295–301.

A discussion is given of the present status of diagnosis and prognosis of carcinoma of the stomach. The traditional conception of gastric carcinoma is in need of revision in the light of present knowledge. The causes of delay in the earlier diagnosis and treatment are due to

several factors: procrastination, incomplete examination, failure on the part of the laity as well as of the physician to realize the gravity of dyspepsia having its onset in middle or late adult life, and obsolete teaching and textbooks. There may be few symptoms or signs in certain cases, or the lesion may be well advanced before tangible symptoms occur. The symptoms are largely dependent on the site, extent and degree of motor impairment. Diagnostic teamwork makes earlier diagnosis and better prognosis possible. One patient in four has an operable lesion.

Carcinomatous ulcer, usually simulating benign ulcer, is more common than is generally supposed. Every gastric ulcer is potentially a carcinoma. Eight per cent of carcinomatous ulcers occur in patients under forty years of age. Achlorhydria is present in 4.5 per cent of chronic benign gastric ulcers in patients past middle life. The necessity for diagnostic observations and laboratory examinations or exploratory operations is in inverse ratio to the skill of the roentgenologist. Roentgenologic criteria of inoperability are more accurate than those of operability.

Intrinsic gastric lesions that simulate carcinoma are gastric syphilis, lymphosarcoma and benign tumor. Extrinsic lesions are carcinoma of the pancreas, carcinoma of the duodenum and advanced disease of the gallbladder or carcinoma of that organ. Of various constitutional diseases that have symptoms like those of carcinoma pernicious anemia is the most important. Exclusive of direct extension or metastasis to other organs or tissues, the most unfavorable index to prognosis in general is perigastric lymphatic involvement; 52.5 per cent of patients without lymphatic involvement were well and free from recurrence three years after operation. In the group with lymphatic involvement the percentage was reduced to 18.

Granger, Amédée. New position for making roentgenograms of the mastoids. *J. Am. M. Ass.*, Feb. 5, 1927, lxxxviii, 372–376.

An examination of the mastoid regions is made from two roentgenograms: (1) a lateral view made in the Law position, and (2) a petrous bone view made in the Arcelin position. The technique and device necessary for obtaining uniform and satisfactory roentgenograms was described by the author in 1925 and is again briefly described for the benefit of those who have not read the original article.

A two years' experience with this technique has demonstrated definitely and positively that the petrous bone view is far superior to the other for the accurate and precise diagnosis of disease conditions of the mastoids. With a good Arcelin roentgenogram it is possible to state that the periantral, the periantral and zygomatic or all the cells including the tip cells are involved, and that the cell trabecula in one, two or all three groups can or cannot be seen. A report is given of a case in which diagnosis was made of a Bezold mastoid with a perforation of the tip. Such a diagnosis could not have been made from a Law roentgenogram.

The author is thoroughly convinced that the petrous bone view has a superior diagnostic value, but it is very difficult to secure. A description is given of method designed to overcome these difficulties. This is the roentgenography of the petrous bone in the Granger position.

The technique is as follows: (1) The mastoid localizer is fitted with a 50° angle block. (2) A cassette covered with the localizer equipped as described above is placed on a 15° angle block with the inclination toward the feet of the patient. (3) With the patient lying on his back, his head is placed with the vertex resting on the cassette and one side of his head against the 50° angle block so that the sagittal plane of the head will lie parallel to the latter. The nose will be within the adjustable upright supports, the septum against the lower and the forehead against the upper one. The central ray is directed through a point 2 inches in front and 1 inch above the external auditory meatus.

This new Granger position eliminates the technical difficulties and limitations of the Arcelin position, while it retains all the advantages over the Law position.

Haggard, William D. Differential diagnosis between gastric and duodenal ulcer and gallstones. *J. Am. M. Ass.*, Apr. 2, 1927, lxxxviii, 1050–1053.

The great majority of gastric and duodenal ulcers, as well as the multitudinous cases of gallstones and associated lesions, are not easy of detection. Many times the symptoms are overlapping and confusing. The symptoms may often obscure the real lesion. The accuracy of the roentgen ray in the visualization of diseases of the upper alimentary tract tends to throw the physical examination somewhat into the background. This is not true, however, of the history because in many cases, particularly of duodenal ulcer, a correct interpretation can be had in a very considerable percentage of cases by the history alone. The pain associated with gastric ulcer has a definite time relation to the intake of food usually, whereas the epigastric pain due to gallstones does not

have a tangible relation to food, the pain being more often referred.

The roentgen examination for gallstones is not as satisfactory as that for ulcer but it is helpful as a matter of routine. The Graham method is of much use. Thoroughgoing history taking, careful physical examinations and clinical insight have not been discredited by modern laboratory and roentgen-ray methods, and are still paramount in interpreting the available evidence in the correct diagnosis between gastric and duodenal ulcer and gallstones.

KINDEL, DANIEL J., and HAYHURST, EMERY R. Stereoscopic x-ray examination of sandstone quarry workers. *Am. J. Pub. Health*, August, 1927, xvii, 818–822.

An examination of workers engaged in the sandstone quarries of Ohio was made by the Division of Industrial Hygiene of the Ohio State Department of Health. The study was intended primarily to determine the incidence of silicosis and tuberculosis in employed persons; and the roentgenological technique was the method chosen because it yielded permanent records, and the examinations could be performed easily. The authors acknowledge the assistance of Dr. Kennon Dunham of Cincinnati who reviewed all the films that were diagnosed as tuberculosis, and checked over the classifications of silicosis. There were 919 men employed at the quarries studied and all but 2 received roentgen examination.

The films were divided into six groups: (1) Those which were essentially negative included 408 men, or 44.4 per cent. (2) Increased fibrosis was found in 238 men, or approximately 25.9 per cent. (3) Beginning silicosis was found in 183, or 20 per cent. The roentgenographic features in this group were characterized by generalized fibrosis involving the bronchial trunks radiating to all parts of the lung field, together with diffuse, discrete, punctate mottling which seemed to follow the bronchial trunks into the lung substance and which in the stereoscope appeared as buds on the branch of a tree.

(4) Moderately advanced silicosis was found in 46 men, or 5 per cent. (5) Advanced silicosis was found in 18 men, or 2 per cent. (6) Silicosis with tuberculosis was found in 19 cases. This last observation was rather astounding inasmuch as workers not engaged in dusty occupations are said to show about the same rate of tuberculosis incidence, whereas the tuberculosis mortality and morbidity rates in workers in occupations similar to this have been stated to be much greater. Summing up, it was found that 646 men, or 70 per cent, of the total showed essentially negative roentgen findings, while 266 men, approximately 30 per cent, showed distinct evidences of silicosis.

In this study, the inhalation of silica dust on the job is apparently not productive of a larger than normal tuberculosis incidence. In the grindstone turning department, 21 out of 27 employees showed evidence of silicosis. Although silicosis may appear rarely after short exposure (one to three years) to the dust, the great majority of cases occur after an exposure of ten or more years. Symptoms are a negligible factor as an index to the prevalence of silicosis or tuberculosis in this particular study since they were found equally in both the negative and positive cases.

LEVISON, LOUIS A. Spontaneous ventriculography from ruptured brain abscess. *J. Am. M. Ass.*, March 19, 1927, lxxxviii, 921–923.

A report is given of a case occurring in a boy aged eleven, the case being noteworthy for two reasons, first, spontaneous rupture of a brain abscess into the lateral ventricle and the roentgen-ray record of it are extremely rare, and second, the clinical picture of an acute ventriculitis or an acute ependymitis is rarely seen and its symptomatology has been rarely noted. The occurrence of a very abrupt rise in the temperature to a high point, the sudden appearance of meningeal irritative symptoms, an increase in the stupor or drowsy condition, a rise in the white count and a sudden cloudiness of the spinal fluid marked the syndrome.

MEYERDING, HENRY W. The preoperative differential diagnosis of bone tumors. *J. Am. M. Ass.*, Feb. 5, 1927, lxxxviii, 365–372.

The physician should seriously consider the responsibility of making a positive diagnosis and prognosis from a single roentgenogram. He may recognize the site, size, origin, localization in or invasion of osseous or periosseous structures, and the condition of the cortex and periosteum, but the interpretation of these observations requires broad experience in differential diagnosis. Local and general types must be differentiated and the possibility of inflammatory lesions considered. The presence or absence of invasion is important. Some absorption and production of bone may be found in the tumor, yet the recognition of an osteolytic tumor as exemplified in giant cell tumors is of great value. The condition of the cortex and periosteum aids in differentiation also, as is seen in fibrosarcomas in which absorption occurs from without; and in the benign lesions such as bone

cysts and chondromas in which absorption occurs from within as the result of pressure. The epiphyseal line seems to be a bar to the extension of the tumor as exemplified in osteitis fibrosa cystica, whereas benign giant cell tumors and chondromas usually involve it.

The variation of the architectural appearance of the tumor in the roentgenogram may or may not help in the differentiation but as a rule it is of great help. A benign appearance does not prove its local character. If the local evidence points to malignant disease, the physician should study the lungs roentgenographically for metastatic lesions. The roentgenogram of the lungs is of great value in cases of sarcoma as it provides the earliest indication of metastasis.

For the purposes of the present discussion the author has slightly modified and rearranged the classification of bone tumors of the Registry of Bone Sarcoma so that the tumors progress from the traumatic and infectious through the benign to the most malignant types. It consists of ten groups instead of the original eight. With a history, clinical examination, urinalysis, Wassermann test and roentgenogram, an expert may accurately diagnose 9 cases out of 10. There exists a small group which defies the most experienced until the tumor is explored macroscopically and microscopically. The roentgenogram properly made and interpreted is one of the most valuable, if not actually the most valuable, aid in diagnosis and will alone insure the diagnosis of the majority of bone lesions. Seven typical cases are reported.

Nemenow, M. Roentgen diagnosis of echinococcus cyst by pneumoperitoneum. *Ann. de roentgenol. et radiol.*, 1926, ii, 82–97.

Roentgen diagnosis of echinococcus cyst of the lung is comparatively easy but that of echinococcus of the abdominal organs has heretofore been considered impossible unless the wall of the cyst were calcified. The author gives the history and roentgenograms of a case which show that by this method roentgen diagnosis of such cysts is possible, which is very important as 75 per cent of all echinococcus cysts are in the abdominal organs. The patient was a woman aged forty-nine who was sent to the hospital for a slowly growing abdominal tumor which gynecologists had diagnosed as probably being a cyst of the ovary. A roentgenoscopic examination was made after insufflation of oxygen into the abdominal cavity and a series of roentgenograms, including one of the whole abdomen and pelvis in the posterior position, one in the genupectoral position with the plate applied to the abdomen, one in the same position with the tube applied to the right side and ones taken from in front and behind with the patient standing. They showed a large number of round bodies of various sizes in the abdomen. Some of these bodies were immobile and seemed to be connected with abdominal organs, the left lobe of the liver, the spinal column and the root of the mesentery. Others were very mobile and one of them the size of a grape was evidently suspended from the liver. One in the region of the left lobe of the liver obviously lay in the liver tissue. There seemed to be only one possible interpretation, namely that it was a case of multiple echinococcus cysts of the abdomen. Operation confirmed the diagnosis. The mobile cysts were attached to the omentum and mesentery which enabled them to move freely.

ROENTGEN AND RADIUM THERAPY

Bellucci, Bruno. A new method of epilation in trichophytosis of the scalp. *Radiol. med.*, June, 1927, xiv, 485–493.

The modification of the roentgen-thallium method of epilation in trichophytosis of the scalp reported by Dr. Bellucci consists in using two large lateral fields and irradiating each of them with half the ordinary dose. He reports 15 cases in which this method has given excellent results. The advantages of the method are that it obviates any danger from the toxic action of thallium or the roentgen dosage and that the results are absolutely certain.

Bolschakova, M. Roentgen therapy in bronchial asthma. *Ann. de roentgenol. et radiol.*, 1927, ii, 240–247.

Among the 24 cases of bronchial asthma which the author has treated 18 were treated by roentgen irradiation of the chest. In the first 3 cases he used low doses of penetrating rays applied alternately on the left and right sides of the thorax. In the other cases the thorax was irradiated simultaneously in front and behind; field 30 × 30 cm., focus distance 50–60 cm., filter 0.5 mm. zinc and 3 mm. aluminum, Neo-intensive apparatus, Coolidge tube, charge 4 ma., current 200,000 volts. Twelve of the patients were having almost daily attacks when the treatment was begun. With regard to the results the cases are divided into five groups. The first group included 4 cases. In these the treatment not only suppressed the asthmatic attacks, but also all the other symptoms, such as cough breathlessness, etc. In the second group there were

2 cases; the patients' condition was considerably improved by the treatment; the crises stopped; occasionally cough and dyspnea reappear but the patients are able to work. In the third group of 3 cases the immediate results were very satisfactory but the time is too short to judge of the final results. In the fourth group of 6 cases the treatment had no effect. In the fifth group of 3 cases the results are not known as the patients withdrew from treatment after the first series of irradiations. In one case of the fourth group the attacks not only reappeared but seemed to be worse than before. In 2 of the cases of the fourth group after irradiation of the thorax had failed irradiation of the spleen was tried but with only temporary improvement.

Bucky, G. Real surface therapy and its relations to the internal organs. *Strahlentherapie*, 1926, xxiii, 136–142.

The fundamental axioms underlying treatment of skin conditions are the following: (1) The germinal layer of the skin should not be injured. (2) The rays traversing the skin are more or less useless for purposes of therapy. (3) Absorption of rays in the tissues beneath the skin is undesirable. (4) With increase in ray absorption within the skin the energy required to produce a biological effect becomes smaller. This implies the utilization of extraordinarily soft roentgen rays; and a special apparatus is necessary for their production. Numerous experiments and measurements have shown that a maximum of 10 to 11 kv. should not be exceeded in the operation of the generating apparatus. The average wave length of these extra soft rays lies between 1.5 and 2.2 Å.

The erythema produced by these rays is a deep red coloration with a pronounced tinge of brown. The patent period is very much reduced, being four to five days at a maximum, but with larger doses it appears immediately after irradiation. In contradistinction to the early erythema, it remains constantly visible from fourteen days to three weeks. Blisters and ulcers may be produced, but they are harmless and painless and heal after three to four weeks. The patient never experiences more than a mild itching. The pigmentation following is very pronounced and appears in eight to ten days. Epilation does not result from the irradiation with these rays. Such sequelae as atrophy, scarring and telangiectasis have not been observed, although some of the cases have been treated more than 2¼ years ago. In all cases recovery was complete and apparently normal. It is believed that the limiting voltage beyond which irradiation will cause telangiectasis lies between 10 and 15 kv. The intensity is a minor factor.

The practical advantages in utilizing these rays are enumerated as follows: (1) practically complete safety; (2) very striking cosmetic results; (3) the possibility of replacing altered skin with normal; (4) a considerably reduced time of healing; (5) no necessity for repeated irradiations; (6) the extension of the field in which this treatment is indicated (e.g., scrotal skin, general irradiations of the skin without affecting the deeper organs). A striking observation is the fact that a small irradiation over an area of a square centimeter causes a typical drop in the blood leucocyte count within five to ten minutes.

Bucky, Gustav, and Manheimer, Olga. Radiant energy, skin and blood pressure. *Strahlentherapie*, 1926, xxiii, 264–271.

This is a fourth contribution on the properties of roentgen rays of long wave length (produced by 6 to 12 kv., 2.19 to 1.44 Å). It was found in the present experiments that exposure to these radiations caused a decrease in peripheral leucocytes; and this is taken to mean that the rays exert an effect upon the autonomic nervous system in the skin. It was also shown that this shift in the leucocyte count occurs independently of the blood pressure. Assuming that biological effects depend exclusively upon the absorbed radiant energy, one cannot explain the immediate blood changes following irradiation as a skin reaction, for isolated skin irradiations with these rays cause no alteration in the blood pressure although the absorption in the skin for these rays of long wave length is at least equal biologically to that of ordinary roentgen rays (as measured customarily in terms of the erythema reaction). From this viewpoint it appears necessary to distinguish different forms of roentgen stimulation of the autonomic nervous system and it may be that the rays produce an effect depending on the site of stimulation (centers or organs of perception).

Assuming, on the other hand, that the wave length determines the biological effect, it would be necessary to ascribe the differences in the skin reaction after exposure to long roentgen rays and to the ordinary roentgen rays to a specific effect of each wave length.

Charapow, B. I. Treatment of syringomyelia by *x*-rays. *Ann. de roentgenol. et radiol.*, 1926, ii, 133–139.

Since 1921 the author has treated 14 patients having the classical picture of syringomyelia

by roentgen rays. He used an 8 to 9 Bauer tube about 9 cm. in diameter, a focal distance of 16 cm. and a dose of 1 to 2 H. At first he used a filter of 3 mm. aluminum, later of 0.5 mm. zinc and 1 mm. aluminum. A treatment was given once a week. A series was composed of 6 treatments in which altogether 12 to 18 H was given. The number of series was determined by the course of the disease. The series should be given at intervals of not less than a month. Of course the details vary to a certain extent depending on the case. Whatever the mechanism of its action roentgen therapy seems to destroy glious tissue and free the remaining cells so that they are restored to active life. In all the cases pain sensation was restored and temperature sensation improved and the strength of the muscles and motor power were increased. In one case a reaction of degeneration in the electrical stimulability of the muscles was restored to normal. Pain sensation was the first to be restored. The older the process, the more rapid the restoration of pain sensation; it often began after the second treatment but progressed slowly, while in patients who had only had the disease four, five or six months reestablishment did not begin unti after 5 or 6 treatments but it then progressed rapidly. With proper technique roentgen treatment is absolutely harmless for the normal tissues and it is the best treatment so far known for syringomyelia.

Dautwitz, Fritz. Observations from 1912 to 1924 on the radium treatment of thirty chronic leucemias. *Strablentherapie*, 1926, xxiii, 107–135.

Examples are cited showing that radium treatment, in addition to causing prolonged remissions and thereby lengthening life, is also able to produce considerable improvement in the blood picture both qualitatively and quantitatively in chronic lymphatic leucemia. The author's observations in this respect are quite different from those reported by others who could observe no such striking changes in the blood picture after radium treatment of lymphemia as after radium treatment of myeloid leucemia. The author also has observed a striking difference in the effect of gamma and roentgen rays in that the former under specific conditions of application are still able to influence favorably roentgen insensitive or roentgen resistant leucemias without producing disturbing side reactions. The lymphatic form of leucemia reacts more profoundly to radium than it does to roentgen rays.

Early in his experience, the author found that owing to variation in individuals it was impossible to designate any single dose as a leucemia dose. Nor was it possible to adhere to any rigid plan of treatment in chronic leucemia, because the applications were varied according to circumstances, especially in those individuals who had previously received roentgen treatment and had to be protected against possible skin injury. One cannot at the beginning of a radium treatment foretell the intervals and in how many series the radium should be applied. It is pointed out that in the case of a patient with leucemia, a skin injury may necessitate cessation of radium applications with the resulting possibility of shortening the patient's life. A treatment usually lasted six to ten hours with applicators containing 90 to 120 mg-ra-el. Experience and constant observation of the blood picture indicate when a series of treatments is finished or must begin. None of the author's cases has suffered injury to the skin or the deeper organs, as a result of repeated radium applications.

Debicki, Joseph H. Roentgen rays and the race question. *Strablentherapie*, 1926, xxiii, 187–190.

The author points out that the use of roentgen rays for the sterilization of the unfit is a convenient, harmless and entirely satisfactory method of procedure. It should be carried out to prevent production of offspring by individuals who are afflicted with pathologic, somatic or psychic defects which are inheritable. Among these may be enumerated habitual alcoholics, incurable mental cases, epileptics, idiots, psychic degenerates, those suffering from hopeless nervous diseases and finally those with severe syphilis or tuberculosis.

Giese, E., and Ossinsky, V. Roentgen therapy of syringomyelia. *Ann. de roentgenol. et radiol.*, 1926, ii, 127–132.

In 1924 the authors commenced treating syringomyelia by roentgen therapy. It would perhaps be more correct to say that they treated gliosis of the spinal column for after cavities have formed no treatment does any good. But as there is no way of telling clinically whether cavities have formed or not all cases should be treated. The length of time the disease has existed is no indication of the stage to which it has advanced for they had better results in 3 patients who had had the disease five, seven and thirteen years than in others who had had it for two, three and four years.

They have treated 14 patients, 8 women and 6 men from twenty-three to forty-six years of age who had had the disease from two to

thirteen years. In 13 of the cases the process was localized in the cervical and dorsal parts of the cord and in 1 in the dorsal part only. In 5 of the cases it had extended to the medulla and in 2 to the lumbar part of the cord. In all of the cases there were changes in temperature and pain sensation and in 7 cases in tactile sensation also. In all of the cases there was amyotrophia and deviation of the spinal column and in 5 there were also trophic disturbances of the skin, bones and joints. All had more or less marked signs of paresis or paralysis of the upper and lower limbs.

Only deep roentgen treatment is effective. They used a Coolidge tube, 4 ma., with a filtration of 0.5 mm. zinc and 3 mm. aluminum. The whole or a part of the spinal column was irradiated, depending on the extent of the process. Generally they irradiated 1 to 3 fields 3 to 4 cm. broad and 8 to 15 cm. long, the surrounding parts being protected by leaded rubber. The rays were directed perpendicularly to the spinous processes. They used 3/4 of an erythema dose on each field and the treatments were repeated at intervals of one to two days. In this way the spinal cord was given about 45 per cent of an erythema dose. The series of treatments was repeated after an interval of two to four months, depending on the course of the disease.

The improvement in the trophic disturbances and the disturbances of sensation and motion were so marked that the authors think the treatment is to be urgently recommended.

Heyman, James. The treatment of inoperable carcinomas of the female pelvic organs. *Strahlentherapie*, 1926, xxiii, 15–30.

It is emphasized that radium treatment, like surgical treatment, can yield satisfactory results only after the patient has been thoroughly examined and with a full knowledge of the useful limits to which the treatment can be pushed; and provided further, that a carefully worked out technique is followed by one with adequate experience. The method is pregnant with dangers for the tyro without offering the possibility of obtaining results comparable with those yielded by surgery.

The method of treatment pursued at the Radiumhemmet, Stockholm, is based in principle upon that devised by Forssell in 1913. The radium is employed in the form of salt and applied as a rule in Dominici tubes. As a rule only three radium applications are given. The second is given two weeks after the first and the third three weeks after the second. If possible at each of these periods radium is applied in the vagina as well as in the uterus. The duration of a single treatment is about twenty-two hours. In the uterus a dose of 33.7 or 40.1 mg-el. is applied three times, i.e., a total dose of about 2220 to 2640 mg-el-hr. In the vagina dose of 70 mg-el. is applied three times, i.e., a total dose of about 4500 mg-el-hr. In all cases the radium is filtered through 3 to 4 mm. lead. Since 1919 a more concentrated treatment has been attempted, the number of applications being reduced to two of thirty-two and twenty-four hours' duration respectively. In these cases the total dose for the vagina was limited to 4000 mg-el-hr. Any attempt at surgical intervention of any kind, e.g., cautery and excochleation, at the beginning of the treatment is considered absolutely contra-indicated. Within the first six months a second treatment is never attempted. If in six months after the three applications the tumor has failed to disappear or if a recurrence has developed, the treatment may be repeated, although it is preferred not to begin any further treatment until a year after the first application.

Treatment with roentgen rays is employed only in exceptional cases. Combined radium-roentgen treatment has been abandoned because it was found that the results were not better but rather worse than after radium treatment alone. Roentgen irradiation in conjunction with the first series of radium applications is now employed only in those cases having extensive lymph gland metastases at the very beginning. Roentgen rays are also employed in those cases suffering continued pain due to radium treatment, and also in cases where recurrence appears in the parametrium. The roentgen treatments employed avoid massive doses. Each field received two or three times one-third of a skin erythema dose, the doses being administered daily or every other day. The irradiations are usually distributed over two anterior fields and one posterior, the rays being filtered through 0.5 mm. Cu and 1 mm. Al.

Some statistics of the results obtained at the Radiumhemmet are presented in tables.

Lane, Laura A. Radium in ophthalmology. *J. Am. M. Ass.*, Jan. 22, 1927, lxxxviii, 232–240.

Experience in treating patients has shown that in most conditions the best results are obtained with gamma radiation in comparatively small amounts administered over an extended period of time. It has also been found that the physical condition of the patient has much to do with the response to radium and the result. One cannot get results where

the basal metabolism, for example, is lowered. Individual study of the patient, the type of the lesion to be treated and minute details in the application of the radium are very essential to attain the best clinical results.

The author presents an extended summary of experimental work on the eyes of rabbits. In a series of six experiments using silver tubes with varying strengths of radium, definite change in injury to the rabbit eye was demonstrated in all cases except with 15 and 25 mc. quantities of radium. The effect of unscreened bare tubes to the rabbit eye is decidedly caustic and injurious. Gamma radiation heavily screened with platinum appears to produce little injury to the eye tissues except in the larger amounts. In a series of 23 rabbits treated with different amounts of radium the intraocular tension was found to be increased in all animals but one. There is evidence of delayed action and remote effects of radium, particularly after the use of larger amounts.

Manheim, Sylvan D. A "fluoroscopic" duodenal bucket. *J. Am. M. Ass.*, Feb. 26, 1927, lxxxviii, 644.

The great difficulty observed with the Einhorn bucket and other duodenal buckets is in determining in the obstinate case whether or not the bucket is within the duodenum. The author has therefore devised a bucket in which can be placed a capsule containing barium sulphate, the outline of which can be readily seen through the spiral opening of the device on roentgenoscopy. The capsule containing the barium is coated with keratin which does not dissolve in the stomach but does dissolve in the duodenum. Thus on roentgenoscopy if the capsule is seen intact the bucket is in the stomach, while if the capsule is not seen the bucket is in the duodenum. The device is described and illustrated in detail.

Muller, George P., and Boles, Russell S. Abdominal manifestations of Hodgkin's disease. *J. Am. M. Ass.*, Jan. 29, 1927, lxxxviii, 301–307.

In Hodgkin's disease primary involvement of the abdominal viscera is exceedingly rare. Little is to be gained from a consideration of the symptoms in the abdominal type since they are variable and may simulate a number of acute and chronic conditions. Symptoms referable to the gastrointestinal tract are usually present when the abdominal viscera are affected. Pruritus, diarrhea and the recurrent type of fever are always suggestive; jaundice, ascites and adenopathy may be present. When Hodgkin's disease is suspected, biopsy of an affected gland should be performed. The classic histologic picture of the disease is rarely wanting when the disease is present. In atypical forms confirmatory evidence is usually supplied by frequent blood examinations, for the blood picture is fairly characteristic.

Hodgkin's disease of the abdominal type must be differentiated from tuberculous peritonitis, at times from typhoid fever, from lymphosarcoma of the retroperitoneal glands, from the splenomegalies (particularly leucemia and splenic anemia) and occasionally from splenomegaly of the Gaucher type, Banti's disease and von Jaksch's anemia. Radical surgery may be considered when the external evidence indicates that the process is chronic and non-progressive, when some function is interfered with by pressure and when splenomegaly persists after irradiation.

In the treatment of Hodgkin's disease the best results in the way of temporary amelioration have been obtained by general and local roentgen therapy. Such therapy should be directed primarily to the abdominal deposits. The prognosis of Hodgkin's disease is apparently hopeless. Three cases are reported.

Neill, William, Jr. Radium in the treatment of menopausal hemorrhage without demonstrable lesiou. *J. Am. M. Ass.*, June 11, 1927, lxxxviii, 1867–1868.

Intrauterine radium therapy for menopausal menorrhagia is the treatment par excellence. It can be given without risk and is indicated in all cases in which there is not a satisfactory response to rest and the customary plans of treatment. With a single treatment, a complete cessation of the hemorrhages can be effected. The local and general symptoms are usually of a shorter duration and less pronounced than in the unprovoked menopause. Such serious sequelae as arthritis, arteriosclerosis, psychosis or untoward blood changes are not attributable to the radium. There is an invariable improvement in health and a feeling of betterment after the treatment.

An internal application is preferable in that it secures the opportunity for thorough examination under gas with curettage to check immediate hemorrhage as well as the imperative, never-to-be-neglected pathologic study of the endometrium. Moreover, radium is most desirable when the patient is too ill to submit to surgery. The gynecologist should therefore give the first place in his consideration to radium in all severe hemorrhages of a benign nature at the time of the menopause. Should

radium fail in rare instances an operation can still be done.

Nemenow, M. I. Experimental roentgen cancer in man. *Ann. de roentgenol. et radiol.*, 1926, ii, 144–147.

There is no longer any doubt that roentgen and radium rays or other chronic irritants may cause cancer. This has been proved in experimental tar cancer. The author describes a case in a patient fifty-two years of age who had had eczema of both hands for fifteen years. He was given roentgen irradiation over the backs of both hands with a soft tube and no filter. Each irradiation lasted five minutes. The dose given at one treatment was not more than 1 H. He was irradiated once a week for three weeks and the fourth week no treatment was given. This was kept up for four years from 1912 to 1916. The treatment was then interrupted on account of the war but in 1918 he was given two series of irradiations for periods of five minutes. In 1922 he first noticed a growth on the back of the right hand which grew rapidly until it was necessary to amputate both forearms. He died after several months of metastases in the axillary glands and mediastinum.

In all cases of roentgen and experimental cancer the irritant must act for a long period of time. In the above case the irritant was applied regularly for four years and then at intervals for two more. The growth did not develop until 1922, six years after the regular irradiations had been discontinued.

Palugyay, Josef. Measuring and adjusting device for the roentgen irradiation of carcinoma of the neck of the uterus. *Strahlentherapie*, 1926, xxiii, 191–192.

Brandess recently described a similar instrument based upon the same idea. The author points out, however, that the construction of his device is more advantageous than that suggested by Brandess. The advantage claimed is that the Palugyay instrument permits the determination of the fields and their adjustment with the simultaneous setting of the roentgen tube, whereas the Brandess device requires separate adjustments and the consultation of a table for making the correct placement of the roentgen tube with respect to the patient.

Read, J. Marion. Graves' disease. *J. Am. M. Ass.*, May 28, 1927, lxxxviii, 1697–1699.

It is encouraging that year by year we acquire more skill in the management of patients with Graves' disease, thanks to perfection in surgical and irradiation technique, and recently, to realization of the benefits and limitations of iodine therapy. But is it not significant that these therapeutic results have not offered a clue to the cause of this disease? This in itself is enough to raise the suspicion that none of the current theories on which therapy is based will ultimately prove true. The seeming success with which roentgen-ray and surgical treatment have controlled Graves' disease is cited as one of the important factors in discouraging inquiry into the etiology. In a self-limited disease running a prolonged course marked by remissions and recrudescences, the "post hoc" fallacy must be avoided in evaluation of therapy. In the case of surgery the theoretical considerations have been largely abandoned for it has developed that the degree to which "hyperthyroidism" is checked bears little relation to the amount of tissue removed.

Schaaff, Johanna. Roentgen treatment of mediastinal tumors. *Strahlentherapie*, 1926, xxiii, 297–312.

From 1913 to the beginning of 1926 there were observed 70 cases of mediastinal tumor which had received roentgen treatment. The older cases were irradiated with ionic tubes and relatively weak current-generating outfits while the later ones received treatment from more modern apparatus. The rays were filtered through 1 mm. Al plus either 0.5 mm. or 3.0 mm. Zn, focal skin distance 23 or 50 cm. The fields exposed were usually a series of 6.5 × 6.5 or 6 × 8 cm. and in a few cases larger fields of 11 × 11 cm. were exposed. The spark gap varied between 38 and 42 cm., the tube being operated at 2 to 4 ma. The average treatment in cases of lymphogranuloma was one-third to one-half the skin erythema dose and for malignant tumors one-half to one skin erythema dose.

In 35 of the cases the diagnosis was established by biopsy, blood test or autopsy. In the remaining cases the diagnosis was made from the characteristics of the disease, the roentgen finding and partly from the reaction following irradiation.

Of these 70 cases there were 20 who survived more than two years; 16 lived more than three years after treatment; 7 lived more than five years. Of 20 patients who are still under treatment or observation, 5 appear to be cured. These include one metastatic sarcoma (primary tumor sarcoma of the testis) after almost four years of observation, and 4 malignant tumors (not absolutely established) after one,

two and six years' observation. Nine other patients are well and about and without symptoms but still showing mediastinal tumor. Six patients are in bad condition.

It cannot be stated at present that there is any particular technique of irradiation offering sufficient advantages to be recognized as the method of choice in the treatment of mediastinal tumors. One of the requirements for successful treatment is the exposure of all of the tumor to a certain minimal quantity of the rays. This value in the case of true blastomas appears to be always over one-half of the skin erythema dose. A fairly high degree of inhomogeneity in the rays does not interfere with a durable effect. On the other hand, the escape of considerable portions of the tumor from any direct irradiation is quite undesirable. The indirect effects of irradiation make up a certain proportion of the general effect of the treatment but they cannot entirely replace direct exposure. Twenty of the cases are described.

Stern, E. A. Roentgen therapy of nephroses and nephritides. *Ann. de roentgenol. et radiol.*, 1927, ii, 271–277.

In a study of 10 cases including 1 of subacute nephritis, 1 of chronic glomerular nephritis, 1 of chronic tuberculous nephrosis, 1 of renal arteriosclerosis with nephritis, 2 of nephrosis with acute nephritis and 4 of nephrosis with chronic nephritis the author found that under small doses of roentgen rays the amount of urine increases, the edema and albumin decrease, arterial pressure is lowered, the microscopic picture of the urinary sediment changes and the general condition of the patient improves. Whether or not the improvement persists depends on the seriousness of the kidney lesions; the more serious the lesion, the shorter the duration of the improvement but there is always at least a temporary improvement. Functional tests of the kidney, the water test and particularly the concentration test, are important signs of the effect of roentgen treatment of the kidney. In all cases of oliguria or anuria, whether they are accompanied by uremia or not, in which medical treatment and even bleeding have not given results, roentgen therapy should be tried. By analyzing each individual case carefully it will be possible to determine what cases of nephritis and nephrosis are amenable to roentgen treatment.

Thedering, Franz. Sycosis and roentgen epilation. *Strahlentherapie*, 1926, xxiii, 143–147.

The treatment of sycosis demands a cleansing of the infected hairs and one method of producing cure is to remove the infected roots. But even this is hardly sufficient for in some cases the infection involves the skin also. It becomes evident, therefore, that the use of roentgen rays for producing epilation in such cases results in cure not primarily because the hairs have been removed but because the irradiation initiates an inflammatory reaction which overcomes the invading organisms through the allergic reaction that follows. If this reasoning is correct it follows that there is no need for a roentgen dose sufficient to cause epilation, and a much milder dose should suffice. The author asks why employ a dose of 10, 12 or 15 X filtered through 1 to 2 mm. Al, when a simple dose of $\frac{1}{5}$ to $\frac{1}{2}$ X similarly filtered is equally effective and indeed more so?

The present discussion is confined to simple staphylococcus infection going under the name of pustulosis barbae (sycosis simplex) and to deep trichophytosis. The author applies the treatment two or three times in a month, the beard being exposed over three fields each receiving $\frac{1}{5}$, $\frac{1}{3}$ or $\frac{1}{2}$ X (tested with Sabouraud's pastilles). In the meanwhile the beard is given a daily treatment with an ordinary boric ointment. Four illustrative cases are cited.

Warwick, H. L., and Stevenson, H. M. Is there an endocrine factor in otosclerosis? *Acta oto-laryngol.*, 1926, ix, 317–324.

On examining a large number of serial sections of embryonic and mature petrous bones it was observed that in the development of the hollow bones and the labyrinthine capsule, both of which show essentially the same processes at the beginning of ossification, a difference sets in only after the primary marrow spaces have been formed. The columns of cartilaginous ground substance have in part disappeared and the jagged cartilaginous residues are surrounded by bone globules and frequently even by a narrow edge of bone. In the hollow bones the enchondral and reticular bone disappears after complete resorption of these columns of cartilaginous bone, and the bone then consists only of a perichondral reticular bone which is gradually replaced by lamellar bone. In the labyrinthine capsule, on the other hand, the network of enchondral bone bodies becomes more and more compact by continuous apposition of lamellar bone, without any considerable process of resorption. In the labyrinthine capsule of the adult, in contrast to the hollow bones, we find many embryonic constituents, such as cartilaginous residues in the endochondral capsule and recticular trabeculae of bone in the perichondral capsule. These

embryonic islands of cartilage are to be found in greatest profusion at the edges of the fenestra ovalis and in the foot-plate of the stapes, points of election in the new bone formation in otosclerosis.

When the pathological changes of the bones of the auditory apparatus are considered as possibly due to an alteration of the calcium metabolism of the body as regulated by the endocrine system, dysfunction of certain of these glands may possibly be the causative factor in producing a calcium unbalance followed by pathological changes in the bone. Inasmuch as the uninhibited action of the pituitary and thyroid glands in early life results in the calcification of the embryonic cartilaginous residues, especially in the labyrinthine capsule and in the foot-plate of the stapes, until prevented by the counteractivity of the ovaries it seems reasonable to the authors to conclude than an increase in the thyroid and pituitary activity due to the stimulus of a pregnancy and accompanied by a cessation of ovarian action can result in the production of a bony ankylosis of the stapes in the oval window and the formation of islands of new bone in the enchondral portion of the capsule. It is known that certain endocrine defects may be transmitted from parent to offspring and the authors suggest that this may possibly explain the hereditary factor also observed in otosclerosis.

Warwick, H. L., and Stevenson, H. M. X-ray therapy in otosclerosis. *Acta oto-laryngol.*, 1926, ix, 339–343.

In applying roentgen rays to the treatment of otosclerosis in women the authors employ the following technique: The entire thyroid region is irradiated, employing a current of 5 ma., and 80 kv., target-skin distance 40 cm., spark gap 13 cm., filtration through 2 mm. Al. The temporal bone is irradiated through a 4 × 4 cm. portal with the same dosage as for the thyroid region. The region of each ovary is then exposed in the same manner with a dose of 1 H. These treatments are repeated monthly. It is the belief of the authors that the hyperactivity of the pituitary and thyroid glands and the hypoactivity of the ovaries during pregnancy are probably important etiological factors in otosclerosis so common under those conditions. The aim in treatment therefore is to adjust the dysfunction of those glands which may play so important a part and it is believed that this adjustment is quite feasible through the proper application of roentgen rays.

An investigation of the relative susceptibility of the thyroid, parathyroid, pituitary and the ovaries to roentgen rays shows that these glands possess practically the same sensitivity: thus 1 H was found to be a stimulating dose for ovarian secretion and for the stimulation of the pituitary and thyroid; and it requires about 5 H to reduce the hypertrophy of one of these glands.

Wyser, Dorean D., and Mayer, Max D. Therapeutic abortion by means of the roentgen-ray. *Am. J. Obst. & Gynec.*, July, 1927, xiv, 62–68.

A limited experience leads the authors to make a qualified recommendation of therapeutic abortion by roentgen rays if carefully restricted to cases in which all indications have been met, contraindications have been considered and where the necessary accurately tested equipment is available. This method should be considered when the necessity for inducing a therapeutic abortion arises in patients in whom surgical intervention is in itself dangerous, if in addition, the underlying disease permanently contraindicates pregnancies, and if there is at least no serious objection to the induction of artificial menopause. The present technique includes catharsis the night before irradiation, an enema in the morning and a restricted diet. The bladder is emptied at the time of treatment, and a vaginal examination is made to map out the uterus accurately. One to four exposures are given on successive days to a suprapubic field and a sacral field, the latter given with the patient prone, a large pillow under her abdomen. The total dose is measured with the Holfelder apparatus to give about 50 per cent of a skin erythema dose in the gravid uterus, i.e., 15 to 20 per cent above the "amenorrhea dose."

The completed cases in this series number 22, the patients ranging in age from nineteen to forty-two years. The data regarding these cases are briefly summarized in a table.

MISCELLANEOUS

Alberti, W. The question of the biological effect of hard and soft roentgen rays in their relation to the roentgen therapy of skin carcinoma. *Strahlentherapie*, 1926, xxiii, 31–40.

Cytological studies conducted on salamander embryos have shown that the mitoses in the corneal epithelium of these animals respond exactly alike to two doses of roentgen rays exactly equal iontometrically (measured with the Siemens dosimeter and including scattered rays), one of which was produced by 200 kv.

through 1 mm. Cu and the other by 100 kv. through 1 mm. Al. Experiments on other mitoses in tissue cultures and in animal tumors confirmed the practical independence of the biological effect from the ray quality. As a result of these observations it is recommended that the irradiation of skin carcinomas should employ that method which from the purely physical standpoint can produce the greatest injury to the tumor cells with the minimal injury of the healthy surroundings. Specifically, the author's recommendation is the administration of two partial doses with rays produced at the same voltage. The first dose should be filtered through heavy metal and administered over the area surrounding the tumor, and the second dose should be filtered through aluminum and applied only over the tumor. A voltage of 120 to 200 kv. is recommended. The copper filter should be 0.2 to 0.5 mm. in thickness depending on the depth of the tumor, and this irradiation should include a strip 0.5 to 1.0 cm. of apparently healthy skin surrounding the tumor. The tumor itself should receive rays filtered through 1 to 2 mm. Al.

Archibald, Edward, and Brown, A. Lincoln. Dangers of introducing iodized oil into the tracheobronchial system. *J. Am. M. Ass.*, Apr. 23, 1927, lxxxviii, 1310–1315.

Qualitative experiments indicate that no trust can be placed in any presumed antiseptic action of lipiodol. It is emphasized that any organisms carried down with the lipiodol from the buccal cavity or tracheobronchial tree into the alveoli may remain an active source of infection. It is conceivable that retained lipiodol may act as a plug and imprison organisms in the alveoli until able to cause harm.

By one process or another, some at least of the lipiodol is absorbed and is eliminated mainly in the urine. After an intratracheal injection of 20 c.c. of lipiodol the daily elimination of iodine during the first two weeks is about 0.02 gm., according to Forestier. It is nevertheless important to remember that the elimination from the lung does not proceed at a fixed rate in all cases. In this respect, cases have been noted in which the lipiodol shadow by roentgen ray showed up to fifteen months, although in a majority of cases the shadows persist for only a few weeks.

Taking into account the dangers incident to the method of introducing the oil, the authors believe that at least the first injection should be done by the bronchoscopic method for the reason that this is the only method which can yield a satisfactory and visual examination of the injected field. Later injections may very well be done by the indirect transglottic method aided by proper posture. There are certain dangers due to the tendency of the patient to cough and this factor will be a serious one. Moreover, the oil may act as a foreign substance in the lungs, may reduce vital capacity, may cause the retention of purulent secretions and through stasis may initiate the development of a fresh infective process in the lungs. Since it is impossible to regulate the dosage of iodine administered with lipiodol through the intrabronchial route either as to amount or rapidity and duration of absorption, such a procedure is not only irrational from the standpoint of scientific therapy but subjects the patients to the possibility of iodism, may actually bring about in tuberculous patients a sensitization causing activation of quiescent disease and may introduce a possibility of superposing an acute process of the respiratory tract upon the pathologic process already present. Two cases are cited in which there occurred complications after the use of iodized oil. One of these cases terminated fatally but death cannot be positively ascribed to the injection of the lipiodol. In still another case reported there was a subacute sepsis involving the respiratory tract; and the administration of lipiodol provoked an acute pneumonic process from which the patient died.

Reports from the literature are discussed. The conclusion is therefore reached that the introduction of iodized oil into the tracheobronchial system carries with it a certain definite degree of danger from various sources which should be weighed before patients are subjected to its indiscriminate use.

Breitländer, Kurt. How great is the quantity of scattered radiation? *Strahlentherapie*, 1926, xxiii, 79–87.

The quantity of scattered radiation depends not only on the size of the field but also on a series of other factors such as the secondary current curve, the curve of the filament current, etc. So long as there is lack of complete standardization of these factors, every condition of operation will require the determination of its "characteristic" dose increment due to scattered rays. The importance of this becomes apparent from tables presented which cite examples showing the scattered radiation to vary between 14 per cent and 67 per cent of the primary dose.

Culbert, William Ledlie, and Law, Frederick M. Identification by comparison of roentgenograms of nasal accessory sinuses and mastoid processes. *J. Am. M. Ass.*, May 21, 1927, lxxxviii, 1634–1636.

A case is described, the only one on record, in which identification of an individual was obtained through the use of roentgenograms of the pneumatic cells of the skull, or indeed of roentgenography at all. The authors took advantage of a fact well known to otorhinologists, namely, the absolute identity of roentgen-ray pictures taken of the nasal accessory sinuses and mastoid bones in the same patient after lapses of five, ten, fifteen or more years. The unchanging shape, size, contour and relation to neighboring structures of the pneumatic cells of the skull offer a reliable means of personal identification.

In the case under discussion the authors possessed roentgenograms of the patient taken in 1918. In 1925 he disappeared under unusual circumstances and the body when found was disfigured and mutilated, but roentgenograms of the sinuses and mastoid processes were promptly identified. Confirmatory evidence was obtained from a dentist who recognized gold inlays in the teeth of the corpse.

Editorial. The natural and mental hazards of radiology. *J. Am. M. Ass.*, Feb. 19, 1927, lxxxviii, 569–570.

In spite of the tendency of many radiologists and other physicians to attribute to irradiation all instances of sterility in radiologists and others associated with radiology, it has never been established that such failure is much more common among them than among persons who have never been exposed to roentgen or radium rays. From the point of view of practical hazard the structures suffering most seriously from irradiation are the skin, genital glands and blood. The "mental" hazards of radiology may rest on the attitude and knowledge of the radiologist himself, but more often on the attitude and ignorance of physicians unfamiliar with radiology.

The "accidents" resulting from insufficient knowledge and protection during the early years of roentgenology are responsible for the prevalent idea that the radiologist is constantly exposed to great danger. Under present conditions this danger is greatly exaggerated in many quarters.

Heyde, and Saupe, E. Studies on the output and electrical conditions of a high tension rectifier under various operating conditions. *Strahlentherapie*, 1926, xxiii, 217–263.

Numerous oscillograms were taken of the potential and current at the transformer and roentgen tube, and the data thus obtained (combined with measurements of ray intensity as influenced by the primary resistance regulation of the voltage) proved definitely that the introduction of resistance into the primary circuit caused false readings to appear on the so-called kilovoltmeter. The output of radiation was greatly decreased, and the occurrence of high frequency oscillations in the high tension circuit was favored. The introduction of only 2 ohms in the installation studied by the authors reduced the radiation output about 10 per cent, although the readings on the kilovoltmeter and tube current indicator remained unchanged. Ohmic resistances introduced for purposes of adjusting the voltage should therefore find a very limited application, perhaps in the form of resistances for fine regulation intended to bridge the gap between two small steps of the regulating transformer; and for such a purpose under normal operating conditions the authors found a sliding resistance of about 0.1 ohm sufficient. In place of the regulation of resistance there has been suggested constant inductive regulation, and this was studied in connection with a rotating transformer and an automatic regulator. The maintenance of the current strength at a maximal value during a period of fluctuation could be controlled with small automatic maximum shunts; and the latter, in their present highly developed state, are capable of maintaining a satisfactory adjustment of the tube current.

Iasswoine, G. Vital staining in animals after roentgen irradiation. *Ann. de Roentgenol. et radiol.*, 1926, ii, 64–70.

The animals (white mice) were irradiated for periods of eleven and sixty-four minutes, and at varying periods after the irradiation trypan blue was injected. They were killed an hour after the injection of the stain and the kidneys examined microscopically. The animals that were subjected to irradiation for eleven minutes appeared macroscopically to be stained somewhat more intensely than the controls. There was a perceptible increase in the intensity of the staining of the epithelium of the convoluted tubules when the stain had been injected as soon as forty minutes after the irradiation. There was no deposit of granules but the staining was diffuse as in the controls and the nuclei of the cells remained unstained. When the stain had been injected two to forty-eight hours after the irradiation the staining was still diffuse and had remained the same or increased a little. After an irradiation of sixty-four minutes the staining was much more

intense than in the controls or in the animals irradiated for eleven minutes. For the first sixteen to twenty-four hours the intensity of the staining increased in proportion to the time from the end of the irradiation to the injection of the stain. After twenty-four hours the staining was less intense and after forty-eight hours was not much deeper than that of the control animals. The blood of the roentgenized animals was also richer in stain than that of the control animals which seems to be due to a more rapid absorption of the stain at the site of injection.

The concentration in the blood of products of metabolism affects the rapidity of absorption of the stain at the site of injection. A slightly increased content will accelerate absorption but after it exceeds a certain limit it will retard absorption. In the first case as a result of the more rapid absorption at the site of the injection the concentration of the stain in the blood will increase rapidly and in the second it will not. There are many things to indicate that irradiation with roentgen rays increases the content of the blood in products of metabolism. The phenomena of vital staining after roentgenization are evidently due to the increased amounts of products of metabolism and are therefore an indirect effect of the action of the rays.

IRLE, FRIEDRICH, and BERGERHOFF, WALTHER. Filter safety device, filter selector and time selector combined with roentgen apparatus. *Strablentherapie*, 1926, xxiii, 181–183.

This is a description of a device which the authors have invented. The wiring of the apparatus is such that the roentgen machine will not operate unless a filter is in position. The time selector utilizes two clocks, one of which is set for the total time of irradiation desired. The second one is automatically set to cut off the current after the delivery of one skin erythema dose for the particular operating conditions and filtration. Therefore, if the first clock is set wrong, the second clock will automatically cut off the current before a dangerous quantity of radiation has been delivered.

JOLKEVITSCH, A. J. The action of *x*-rays on bacteria. *Ann. de roentgenol. et radiol.*, 1927, ii, 278–297.

The author found that roentgen rays do not have any specific action on bacteria. Chemical agents, such as certain salts, stains, saponin, glycerin, sugar, etc., introduced into the nutritive medium and physical agents such as ultraviolet rays and radium rays have effects very similar to those of roentgen rays. Each species of bacterium has its own individual sensitiveness to roentgen rays. But all the individuals of a species do not have the same reaction; in addition to a specific sensitiveness there is also a well-marked individual sensitiveness. In the action exercised on bacteria by roentgen rays or other chemical or physical agents there are two phases; in the first phase the cells undergo hypertrophy, while in the second they decrease in size or return to normal. Roentgen as well as radium rays have a stimulating action on the vital processes of bacterial cells. They make them pass through their normal cycle of development more rapidly so that they age quicker. That is why the intensity of the changes caused in the cells by the rays depends on the age of the latter. The rays change the normal consistency of the protoplasm of the cell, causing it to coagulate. That is what causes the appearance of fine granules and a certain excess of liquid in the cell. The forms of cells which are generally called involution forms in microbiology are by no means all of the same kind. Some of them are degenerated forms which are about to die, while others are forms of adaptation to unfavorable conditions and are perfectly capable of living and multiplying. Roentgen rays as well as radium rays given in sufficient doses suppress certain vital functions of the bacteria: they cause arrest of their growth, prevent the formation of pigment and slow up or completely stop the motility of the bacteria. The formation of pigment is affected by smaller doses of rays than the function of growth.

JUGENBURG, ANNA. The effects of roentgenization of the stomach region on stomach function. *Ann. de roentgenol. et radiol.*, 1926, ii, 51–63.

The experimental work done by the author on dogs showed that exposure of the stomach to roentgen rays causes both functional and anatomical changes. The degree of the changes depends on the intensity of each individual irradiation and the number of exposures. Small doses, not above the usual therapeutic dose, at first cause a considerable increase both in total secretion and amount of hydrochloric acid. This period of increased secretion is followed by a longer one of decreased secretion, which finally gives place to normal conditions again. Large doses, from 2 to 5 skin erythema doses, cause a marked increase in secretion both quantitatively and qualitatively. A very large dose, 5 skin erythema doses, given at one time may cause a stomach ulcer very like round ulcer of the stomach in human begins without causing any erosion of the skin.

The stomach mucosa on the whole is not very sensitive to roentgen rays and frequent irradiations only cause mild symptoms of fibromatosis of the mucosa. Intense irradiation of the stomach region causes pronounced cachexia. The mucous membrane of the small intestine in dogs seems to be very sensitive to roentgen rays, and comparatively mild doses may cause ulcers. The early general reaction is not caused by decreased secretory function of the stomach as it is seen in cases in which both total secretion and hydrochloric acid are increased.

KLÖVEKORN, G. H., and GAERTNER, O. The effect of roentgen rays on unicellular organisms. *Strahlentherapie*, 1926, xxiii, 148–154.

Experiments are cited showing that bacteria are most easily affected by roentgen rays when they are removed from the culture medium. In agar cultures, the freshly growing organisms are much more sensitive than those in cultures twenty-four hours old. The organisms employed in this study were *Staphylococcus pyogenes aureus*, *Bact. coli* and *B. mesentericus*. The rays were produced in a Müller tube containing a copper anticathode and a Lindemann window. The rays were delivered at a focal distance of 7.5 cm. without filteration, the tube being operated at 9 ma. and 50 kv. effective. Intensity measurements in R units showed 485 R per second at 7.5 cm. distance. The mean wave length of the unfiltered rays was 1.47 A.

KOERNICKE, M., and KÜSTER, A. Are the biological effects due to roentgen radiation itself or to the air altered chemically by the roentgen rays and high voltage? *Strahlentherapie*, 1926, xxiii, 155–160.

This is a preliminary report of experiments in which it was found that the biological effect is primarily due to the roentgen rays. Possibly under extreme conditions a sufficient amount of ozone and nitric oxide may be generated in the air to produce significant effects of their own.

The experiments were done upon young and mature plants and seeds. The seedlings of *Vicia faba* and *Phaseolus vulgaris* were also used. A dose corresponding to 20 skin erythema units was applied in seventy-one minutes and typical roentgen-ray effects were observed, although the exposed objects were washed with a current of fresh air. On the other hand, drawing irradiated air over the plants produced no demonstrable effect.

KOTCHNEFF, NINA. The effect on the sugar content of the blood of intravenous injection of defibrinated blood taken from animals after roentgen irradiation. *Ann. de roentgenol. et radiol.*, 1926, ii, 71–73.

Tables giving the details of the experiments are presented. They show that an injection of defibrinated blood taken from rabbits exposed to irradiation always caused an increase of blood sugar for the first ninety minutes after the injection. Hyperglycemia was at its highest from thirty to forty-five minutes after the injection. The effect of the blood in increasing blood sugar differed, depending on what part of the body had been irradiated. Blood taken from rabbits whose whole abdomen had been irradiated was most active. Blood taken from ones whose heads only had been irradiated was least active. Blood taken from rabbits exposed to small doses of irradiation ($\frac{1}{4}$ to $\frac{1}{2}$ skin erythema dose) caused more intense hyperglycemia than that from rabbits given 2 skin erythema doses over the same parts of the body.

KUMER, LEO. An apparatus for introducing radium tubes in a filter. *Strahlentherapie*, 1926, xxiii, 184–186.

The author seeks to avoid the necessity for exposing the fingers while introducing radium tubes or emanation capillaries into required metallic filters. This is done by providing a massive metal turntable rotating on ball bearings and having a wall of 2 cm. of lead all around. The center is hollowed out to receive the metal shell of the filter. The tube of radium or emanation is inserted into the shell by means of a forceps and packed down tightly. The apparatus is illustrated.

LAZAREW, N. W., and LAZAREWA, ANNA. On the functional changes of the blood vessels after roentgen irradiation. I. *Strahlentherapie*, 1926, xxiii, 41–78.

This is a pharmacodynamic study of the functional condition of the vessels in the isolated rabbit ear after irradiation *in vivo*. One of the ears of the rabbit received roentgen irradiation while the second was untreated. After varying intervals following irradiation (from five minutes to two months) the rabbits were killed, the ears removed and subjected to pharmacodynamic investigation. The other ear of each rabbit served as a control. A large number of experiments was performed and the protocols are given in detail.

The results lead to the following conclusions: The changes of the functional conditions of the vasomotor apparatus of the blood vessels

following roentgen irradiation appear also in the ears after removal. This fact permits the application of the Krawkow-Pissemski method for testing functional condition of the vessels. The roentgen rays cause definite increases in the irritability of the vasodilating apparatus, and this was already demonstrable at the end of the first day following irradiation. With small doses (1.5 skin erythema doses through 1 mm. Al) which produced no visible clinical reactions, this increase in irritability disappeared three week after irradiation; with larger doses (2.5 skin erythema doses, unfiltered) it remained during the two months up to the onset of visible reaction (epilation, hyperemia). At the time that this local reaction occurs and even a little earlier, there is also observed a pronounced dilatation of the vascular bed and finally a decrease in irritability of the vasoconstricting apparatus.

Oksenow, I. The relation between the acidity of the gastric juice and the motor function of the stomach. *Ann. de roentgenol. et radiol.*, 1927, ii, 198–200.

In a study of 45 cases the author was unable to find any constant relation between the acidity and the motor function of the stomach. The emptying time of the stomach is not less than normal in patients with achylia. When acidity is very high the motor function of the stomach is normal or even exaggerated. This latter fact should be verified by a study of a larger number of cases however. The author concludes that it is probable that the motor function of the stomach does not depend on dynamic factors alone, but also on mechanical static conditions, such for example as a high position of the pylorus. The influence of such conditions may completely overcome that of acidity.

Oksenow, I. A. The action of pilocarpin on the motor function of the stomach. *Ann. de roentgenol. et radiol.*, 1927, ii, 201–203.

There have been many contradictions in the reports of different authors on the effect of pilocarpin on the motor function of the stomach. The author's method of studying the question was to make a roentgenoscopic examination of the stomach when it was not under the influence of any drug. The condition of tonus and peristalsis and the emptying time were noted. After one or several days the patient was given an ordinary contrast meal and a second roentgenoscopic examination made. A subcutaneous injection of 1 c.c. of a 1:100 pilocarpin hydrochlorid was then given five to ten minutes after the contrast meal was taken. Roentgenoscopic examinations were then made at intervals so as to follow up the changes in tonus, peristalsis and emptying time. The examinations showed beyond doubt that pilocarpin at first stimulates the motor function of the stomach as shown by the increased rapidity of emptying time. This temporary stimulation is soon followed by a period of fatigue during which small portions of food may remain in the stomach for hours, as is seen in ulcer of the duodenum. The action of drugs of the pilocarpin type ordinarily does not last more than two hours. As pilocarpin stimulates the vagus nerve its action is most pronounced in subjects in whom this nerve has a normal or exaggerated tonus, as shown by the tonus and form of the stomach.

Pétchenko, B. The effect of roentgen rays on amebae. *Ann. de roentgenol. et radiol.*, 1926, ii, 40–50.

Amebae of different varieties were subjected to the action of radium for varying periods of time. Tables are given showing the details of the results. The irradiated amebae showed two typical phases, a phase of stimulation and a phase of depression which is shown morphologically by what the author calls a condition of rest. In the first phase the amebae showed active movements and assumed extraordinary forms. They increased greatly in length and their pseudopods became long and presented very peculiar forms. Their movements were jerky; sometimes they moved in a straight line with an undulating movement of the whole body like that of an eel. Sometimes in elongating they took on a spindle shape with pointed ends, sometimes they assumed the form of small globules. After a short exposure to radium the period of stimulation began gradually and lasted a long time. The more the irradiation was prolonged the quicker it began.

The second phase or period of depression came on gradually. The amebae returned to their usual polygonal form and gathered together in clumps which sent out pseudopods very slowly. The movements were very slow; they were not coordinated and did not have any definite direction, sometimes they even stopped completely. If the irradiation is very short there may be no period of rest. The period of depression is gradually followed by a return to normal. These periods of stimulation and depression are shown by different irregularities in structure. The protoplasm looks watery and shows many vacuoles. The nucleus is hypertrophied and does not stain readily. Evidently the function of the nucleus is very much disturbed. Sometimes the nucleus starts

to divide but the division is not finished; two masses of protoplasm form, connected by a narrow line of protoplasm; after awhile they reunite to form a single cell. Sometimes in place of the usual division into two parts small bits of protoplasm become detached and form dwarf amebae. In many individuals during these phases there are signs of fatty, pigmented and albuminous degeneration.

RAHN, JOH., and KOOSE, W. On the mechanism of the action of hard roentgen rays. *Strahlentherapie*, 1926, xxiii, 195–216.

Experimental studies show that explanted, irradiated, human epidermis and skin of the adult white mouse are considerably less roentgen sensitive than that attached to the intact body, as is shown by the healing of these tissues. It was found that human skin in a Ringer's solution irradiated with a dose up to 3 skin erythema units showed no direct injury by the rays under conditions known to produce a roentgen ulcer upon the intact skin with a dose of only 1.5 skin units. It was found also that 5 skin erythema units delivered to the skin of the white mouse, removed from the body, produced no visible injury. Under certain conditions mouse skin irradiated *in vitro* seems capable of producing a fatal toxic effect when replaced on the animal.

The primary effect of the radiation may be (1) upon the cells; (2) tissue fluid, blood and lymph; (3) the solid (so-called dead) interstitial substance which after cessation of growth remains largely unaltered and undergoes certain aging processes due to its colloidal structure. The importance of the primary roentgen effect upon this dead interstitial substance, taken in the broadest sense, has not been seriously considered heretofore. The authors assume as a working hypothesis that chemical changes are initiated by the roentgen rays in this intercellular medium, for instance on the fibrous tissue, and that this is responsible for the end-effects seen. Some of this substance may be transformed into difficultly soluble substances (some of them toxic), these remaining adsorbed to the unaltered fibrous tissue. This would explain why the tissues suspended in Ringer's solution and thus washed free of the toxic materials remained apparently uninjured.

REID, WILLIAM D., and KENWAY, FLORENCE L. The action of tetraiodophenolphthalein on the heart. *J. Am. M. Ass.*, Feb. 19, 1927, lxxxviii, 540–541.

The reactions observed in many patients following the administration of tetraiodophenolphthalein in the roentgen-ray study of the gall-bladder by the Graham test have often aroused concern as to the condition of the heart. The authors therefore made an electrocardiographic study of 13 patients for direct evidence of cardiac change. However, they were unable to discover any consistent alterations from the control electrocardiogram. It is therefore concluded that the injection of tetraiodophenolphthalein does not have a significant effect on the heart.

REINBERG, S. A. The nephrotomy incision. *Ann. de roentgenol. et radiol.*, 1926, ii, 98–119.

Anatomical descriptions and sketches based on the roentgen examination of the arterial system of the kidney show that there are many irregularities and anomalies in the distribution of the arteries and so it is impossible to determine in advance in any given case just where an incision should be made to fall in the zone between the vascular and non-vascular region. Anatomical investigations show that any deep incision into the medulla of the kidney risks injuring the intrarenal arteries. Superficial incisions of the cortex lying in the external grooves in the kidney are comparatively without danger. Zondeck's incision is comparatively the best of the incisions ordinarily used in nephrotomy, but even this incision with the best technique for nephrotomy frequently injures large arterial trunks and is therefore dangerous. Many surgeons are now advising that the limitations for nephrotomy be restricted and this is justified not only by the above anatomical considerations but also by the high percentage of bad results from this operation.

STENSTRÖM, WILHELM, and REINHARD, MELVIN. Intensity distribution of roentgen rays in the water phantom. *Strahlentherapie*, 1926, xxiii, 88–106.

The water phantom 22 × 30 × 30 cm. was built of wood and sealed with wax. Strips of film were suspended at different depths and exposed under various conditions. The intensity distribution was measured photometrically after development of the film. The most important findings may be summarized as follows: (1) The intensity at any depth falls steeply at the boundary of the beam of rays. (2) The intensity at the middle of any field increases at first with increasing depth; for large field and large focal distance, the intensity at 1 cm. depth is greater than at 1 mm. below the surface of the water. (3) After the intensity has again reached the same numerical value

at a certain depth which obtains at the surface of the water, the intensity in the central ray proceeds to decrease regularly with increasing depth. These results contradict the findings of Dessauer and Vierheller. However, the observations agree with recently reported measurements made with the ionization chamber, such as those by Holfelder and by Rump and Jäger.

A series of charts are given illustrating the isodose diagrams obtained by the authors' method. The photometric method is not entirely satisfactory and it is recommended that both this method and the ionization method be employed in the construction of intensity distribution diagrams for different depths.

Wail, S. S., and Frenkel, S. R. The effect of radium on cell protoplasm. *Ann. de roentgenol. et radiol.*, 1926, ii, 140–143.

In studying the effect of roentgen and radium irradiation on cells the nucleus has generally been the object of study and the protoplasm has not been considered. The authors, on the contrary, devoted themselves to a study of the mitochondria of the protoplasm. They studied the liver cells of frogs in 30 irradiated and 12 control animals. They found that by the use of special cytological methods changes could be seen in the protoplasm of the cells at a time when the nucleus was still apparently normal. Changes could be shown in the cells at a period when it is impossible to distinguish an irradiated cell from a normal one by the usual histological methods. In this way the so-called latent period following irradiation has been shortened and the authors have reason to believe that by further improvement of their method they will be able to prove that the rays act on the cells immediately. The changes produced by radium and roentgen rays are essentially the same.

Whitaker, Lester R. The mechanism of the gallbladder and its relation to cholelithiasis. *J. Am. M. Ass.*, May 14, 1927, lxxxviii, 1542–1548.

It is generally agreed that bile from the gall-bladder is delivered into the intestine after the ingestion of food, but opinions differ widely as to the degree of evacuation and the mechanism involved. An analysis of the problem leads to the conclusion that the contents of the normal gall-bladder are expelled by the activity of its musculature during the digestion and absorption of fat. Proof does not exist that this effect is brought about by a reciprocal action between the sphincter of the common bile duct and the gall-bladder; in fact, there is considerable evidence against it.

Stones can be produced experimentally in animals by interference with the normal mechanism for filling and emptying the gall-bladder resulting in stasis and over-concentration of bile. It is possible that stones are produced in human beings by dietetic habits resulting in stasis. It is also possible that debilitating diseases by reducing the muscle tonus of the gall-bladder favors stasis and the formation of stones. Stones can be forced out of the gall-bladder in experimental animals by the giving of fat. It is probable that the same effect can be produced in human beings by the same means provided the stones are not too large or the disease has not progressed far enough to render the musculature of the gall-bladder impotent.